A methodology to quantify the risks of urbanisation on groundwater systems in South Africa

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It all starts here ™

ABSTRACT

Each year, the urbanised population grows exponentially and due to this growth, cities are forced to expand beyond their manageable borders resulting in greater pressure on the surrounding urban environment. Many South African towns or cities are dependent on surface water for water supply. These resources are slowly being depleted and the dependence on groundwater resources is becoming increasingly important. Due to increased mining, industrial and agricultural activities in South Africa the surface water and groundwater environments have become vulnerable to contamination.

This study aimed to develop a methodology in which the risks of urbanisation can be quantified.

The conceptualisation and qualitative site impact and risk assessments focused on any environmental changes. The urban environment was sub-divided into three distinct areas and analysed separately in order to detect possible groundwater impacts of the water flowing through the urban area. Upstream river flow gauge chemistry by way of tri-linear grouping (piper diagram) of the major anions and cations showed already impacted water due to mining activities north of Potchefstroom. Uranium concentrations in the downstream surface water showed negligible impact as the concentrations remained within the relevant standards over time. Total coliform bacteria concentrations were found to be well above the acceptable levels and these high concentrations are an indicator of water purification inefficiency.

Different qualitative risk assessment approaches i.e. the Environmental Risk Assessment method, Fuzzy Logic and the Depth to water, recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone media and Conductivity of the aquifer (DRASTIC) approach risk assessments were compared and used to determine the most effective way to determine the most likely risks associated with urbanisation.

Different modelling tools namely, analytical element modelling method (AEM) using the Visual AEM program, a finite difference numerical modelling method using Processing Modflow v.8 (PMWin) were evaluated, however due to insufficient data, an analytical approach had to be developed. This approach incorporated logical steps and associated processes to serve as a guide for future urban hydrogeological investigations.

A case study (namely Potchefstroom) was used to test the developed methodology. The developed methodology provides a step by step approach to urban risk assessment, even in areas where there is insufficient data.

Keywords: Urban areas, Groundwater, Risk assessment, Water balance

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LIST OF ABBREVIATIONS

AEM	Analytic Element Model
AMD	Acid Mine Drainage
CHART	Comprehensive Hydrological Assessment & Research Tool
CBD	Central Business District
DTM	Digital Terrain Model
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWA SAWQTV	Department of Water Affairs South African Water Quality Guidelines for Domestic Use Target Values
EC	Electrical Conductivity
GIS	Geographic Information Systems
GRDM	Groundwater Resource Directed Measures
GUI	Graphic User Interface
IDP	Integrated Development Plan
K	Hydraulic Conductivity
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MLAEM	Multi-layer Analytic Element Model
NGA	National Groundwater Archive
NGDB	National Groundwater Database
RMS	Root Mean Squared
S	Storativity
SA	South Africa
SANS	South Africa National Standard
SLAEM	Single Layer Analytic Element Model
SWL	Static Water Level
T	Transmissivity

TDS	Total Dissolved Solids
WARMS	Water Authorisation Registration Management System
WMA	Water Management Area
WSDP	Water Services Development Plan

UNITS OF MEASUREMENT

a	annum
cm	centimetre
d	day
i	gradient
km^2	square kilometre
ℓ	litre
m	metre
m^2	square metre
m^3	cubic metre
mamsl	metres above mean sea level
mbgl	metres below ground level
mg/ℓ	milligrams per litre
mm	millimetre
mS	millisiemens
q	flux
s	second
km	kilometre
Mℓ	Million litres
°C	degrees Celsius
%	Percentage

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CHAPTER 1

1 INTRODUCTION

Each year, the urbanised population grows exponentially, and due to this growth, cities are forced to expand beyond their current borders (increasing residential developments as well as more businesses in the industrial areas) resulting in greater pressure on the urban environment (i.e. water supply, storm water systems and service delivery).

According to Lerner (2005:1), the functions of a city directly affect groundwater conditions, but often these conditions are the last thing to be considered. The mismanagement of sewage- and purification systems as well as poorly built infrastructure has great implications on the groundwater qualities in big cities, especially if an urbanised area is dependent on groundwater for water supply.

Many South African towns or cities are currently dependent on surface water (i.e. rivers, dams, streams etc.) for water supply and these resources are slowly being depleted. Groundwater resources are becoming increasingly important to supplement the water supply requirements. Due to increased urban, mining, agricultural and industrial activities in South Africa the surface water and groundwater environments have become more vulnerable to contamination.

1.1 Study objective

The objective of this study includes the development of a methodology to quantify the risks of urbanisation on groundwater systems; through the application of the following:

- Review of international literature (including first principle impact and risk assessment);
- Developing a methodology based on the result of the literature review; and
- Demonstrating the methodology by means of a case study, namely the Potchefstroom.

1.2 Layout of dissertation

Chapter 1:

Chapter 1 is the introductory chapter which describes the typical problems associated with urbanisation and impacts expected on the groundwater system, as well as a brief description of each of the subsequent chapters.

Chapter 2:

The literature review discusses contamination sources in the urban areas, likely located mainly in the industrial parks and the central business districts (CBD). The implications of urbanisation and the modelling tools are discussed based on the inputs from available publications. Comparative case studies for each of the components are also provided from available publications. Different risk assessment approaches are included and compared.

Chapter 3:

Chapter discusses data sources, data collation and interpretation including the following:

- Groundwater level data;
- Hydrochemistry data;
- Geology;
- Contamination sources, pathways and receptors;
- Qualitative risk assessments; and
- Modelling tools.

Chapter 4:

Chapter 4 discussed the selected case study and a conceptual model for the area.

Chapter 5:

Chapter 5 discussed the risk assessment performed based on the results of the analytical model and will give and overall initial quantification of the urban risk using the following methodologies:

- Environmental Risk Assessment;
- Fuzzy Logic; and
- The DRASTIC method

The shortfalls of numerical modelling are also included.

Chapter 6:

In this Chapter a step by step methodology is discussed in order to define and quantify the urban risks.

Chapter 7:

Conclusions regarding the research are discussed. Recommendations are made based on the results of the dissertation.

CHAPTER 2

2 LITERATURE REVIEW

2.1 Preface

Groundwater resources are becoming increasingly important for water supply in urban areas due to greater surface-water scarcity and potential for contamination from outside sources, using mining as an example. Groundwater generally provides water supply to municipalities for private domestic, industrial and irrigational purposes in the amenity areas (Foster, 2001:188). Some municipalities may abstract water from sources beyond urban bounds for mainly domestic and public uses.

It should be noted that the case study (Potchefstroom) would not yet form part of the discussion in this Chapter. The background and technical information regarding the case study will be provided in Chapter 4.

2.2 Climate

Extensive urbanisation alters the rainfall and evapotranspiration patterns and creates a microclimate over the urbanised area, which could mean higher rainfall in the urban areas than the surrounding rural areas (Foster, 1990:189; Lerner, 1990:60). Contributions to climate change in urbanised areas include the following:

- Unsustainable population growth;
- Expansion of infrastructure due to urbanisation;
- Urbanisation removes a large amount of oxygen (O_2);
- Burning of fossil fuels increasing carbon dioxide (CO_2) emissions; and
- Paved / tarred areas increase temperatures over urbanised areas.

Figure 2.1 shows the microclimate over an urban area, and the urban effects on groundwater recharge. The microclimate increases the rainfall in the major cities and due to the infrastructural coverage in urbanised areas such as pavements, roads and buildings more runoff occurs. The more migrations of populations to major cities from the rural areas increase the pressure of the storm-water management systems, which lead to the infiltration of the possible contaminated water into the underlying groundwater systems.

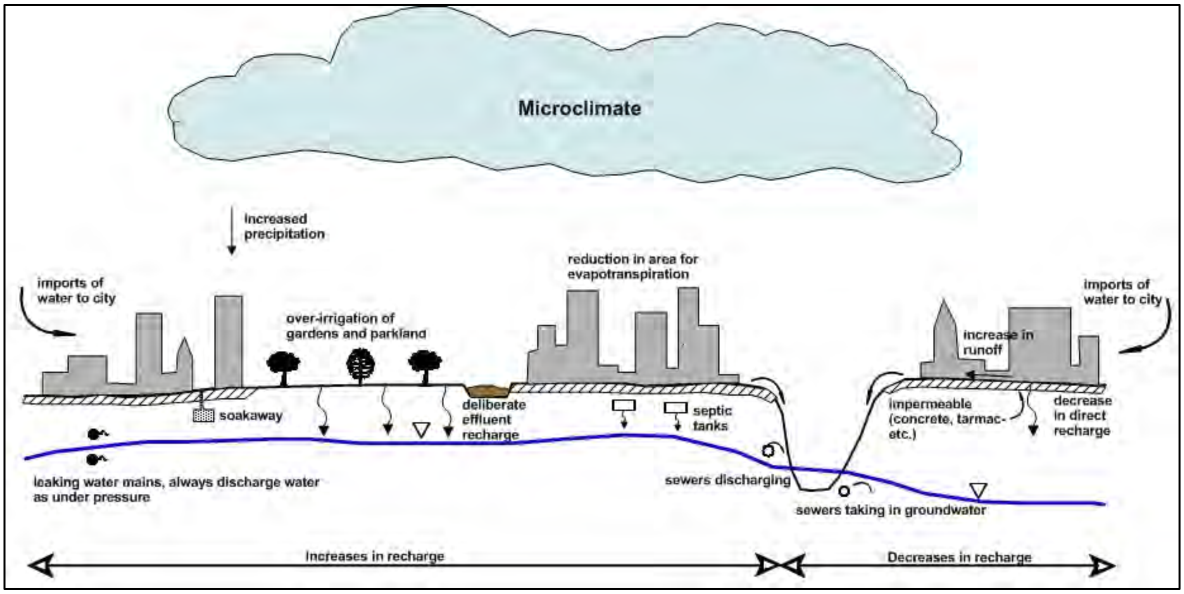

Figure 2.1: Urban effects on groundwater recharge (modified from Lerner, 1990:60)

2.3 Surface cover

According to Foster (1990:190; 2001:186) and Lerner (1990:59), urbanisation typically includes soil compaction, paving and roofing, which will render the surface cover impermeable. Natural subsurface infiltration is significantly reduced, especially in the densely built-up areas. Runoff, peak flow and total flow will increase due to the impermeability of the surface cover.

Amenity areas are more susceptible to water infiltration due to soil permeability and they will compensate for the reduction in infiltration in the main urban areas. The result of this is mounding effects on the natural groundwater table and the development of localised perched aquifers. Stated simply, the increased infiltration of water as a result of over irrigation in parks and leaky effluents from storm water drains into the groundwater systems will result in an elevated groundwater table.

The principle pathways in the water supply networks in urban areas are illustrated in Figure 2.2 (Lerner, 1990:60). The figure depicts the water inflows and outflows in an urbanised area; dividing the uses within the industrialised areas, the domestic uses and where water is disposed of.

There are comparable uses within both the industrial as well as domestic uses where external leaks, effluents and disposal are generated. In some cases the water that leaves the system is transferred to the sewage treatment plants where the water is purified and ‘recycled’ for repeated use.

In the industrial industry the water from external leaks flow into the sewer system, but some water finds its way to local rivers, streams and ponds, which then infiltrate back into the groundwater system.

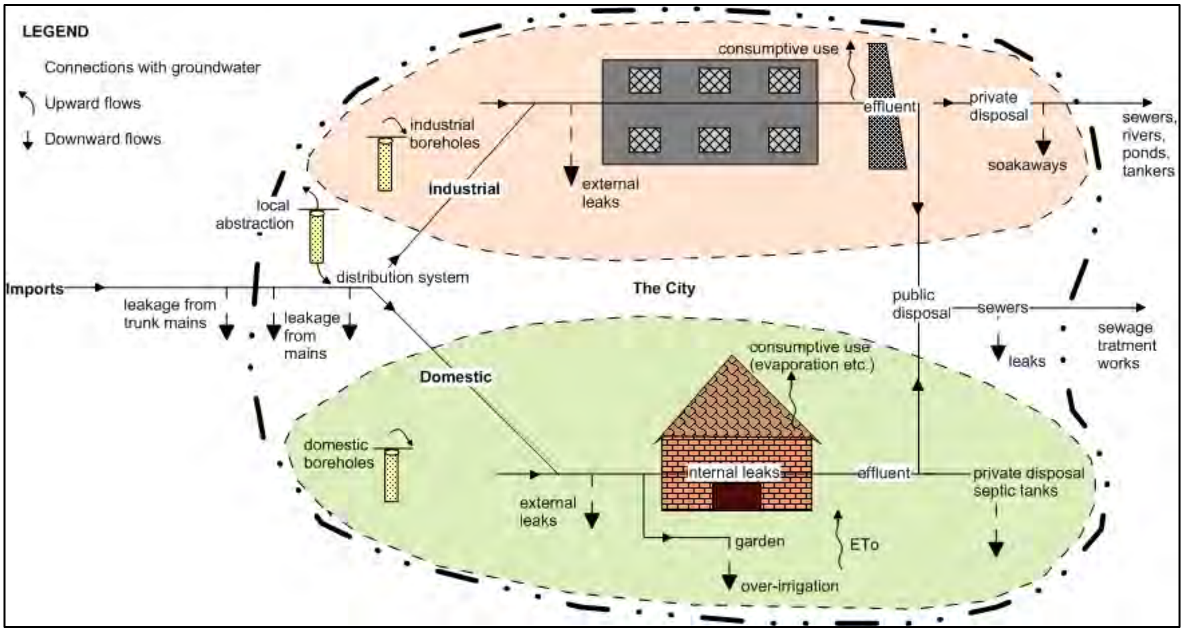

Figure 2.2: Principle pathways in the water supply networks in urban areas (modified from Lerner, 1990:60)

2.4 Recharge and groundwater levels

Vertical recharge and/or horizontal flow are the main controls on aquifer levels. The hydraulic conductivity of the strata overlying the main aquifer can cause the formation of a perched water table, especially in the presence of increased rates of infiltration (Foster, 2001:187). Direct recharge from rainfall is reduced due to the water being transported in storm sewers and other artificial waterways (Foster, 1990:190).

Indirect recharge could be accredited to soakaways from roofs, paved surfaces, reduced evaporation, leakages from water-supply pipelines and seepage due to irrigation and by wastewater inside the city limits (Naik *et al*., 2007:349). These factors have compensated for the effects of surface sealing and have caused additional recharge to groundwater in localised areas. Heavy water abstraction may exceed the rates of recharge and water levels may decrease, which could result in deepening of the boreholes or abandonment (Foster, 2001:193).

Naik *et al*. (2007:359) report that shallow groundwater levels can be found inside the main city limits due to decreased groundwater abstraction, higher reliance on surface water and increased groundwater recharge due to additional supply of surface water.

In Solapur, located in central India, there is a general decline in groundwater levels outside the city limits due to increased groundwater utilization for irrigational purposes (agricultural). The reverse could be true for cities that pump groundwater from within the city limits for domestic use rather than irrigational purposes. Rises in groundwater levels in perched aquifers may pose a danger to the urban infrastructure such as deep collector sewers, main water supplies, septic tanks and building foundations/basements.

The principle recharge sources and pathways in urban areas are illustrated in Figure 2.3. The figure shows the inflows and outflows of water into the urban aquifer. The water used via imported surface and groundwater will end up as wastewater and from precipitation the water will have localised recharge and will run into the stormwater systems.

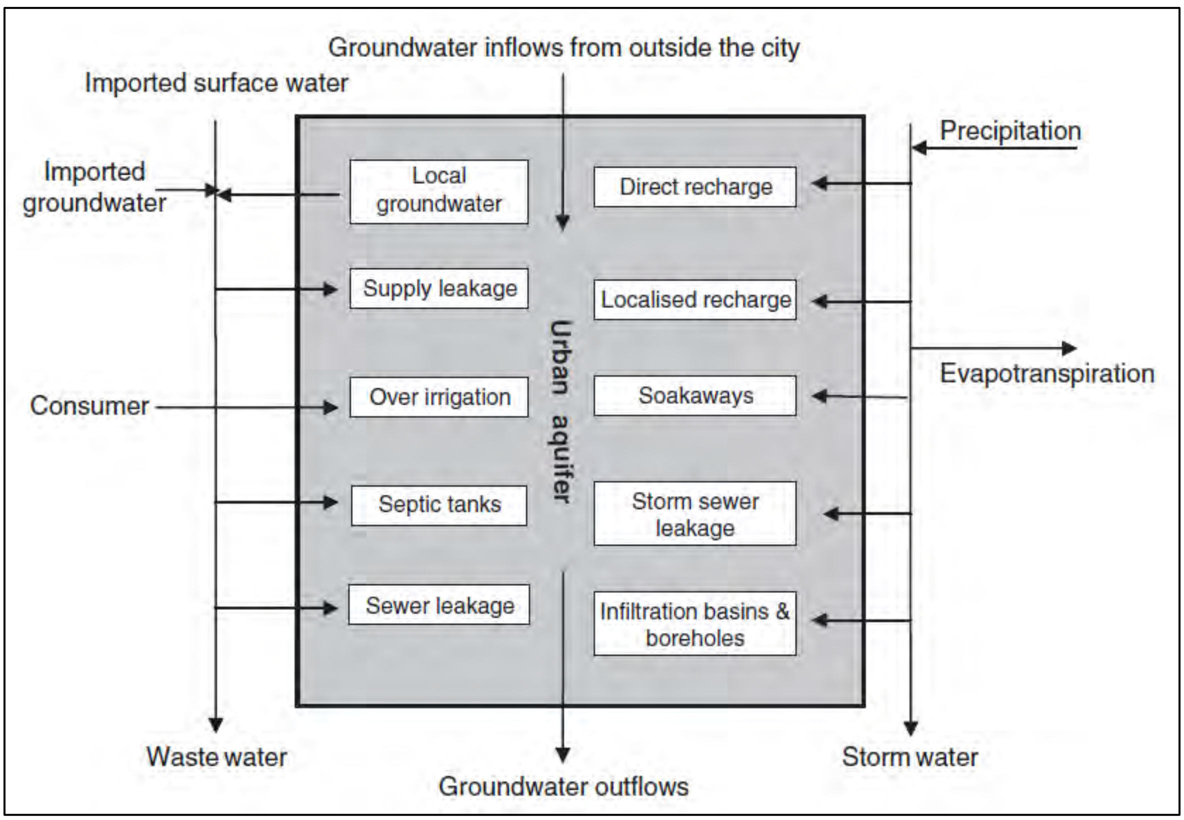

Figure 2.3: Principle recharge sources and pathways in urban areas (modified from Lerner, 2005:2)

2.5 Groundwater quality

Throughout all documentation, common grounds could be agreed upon that the groundwater quality is steadily deteriorating in urbanised areas. According to Foster (2001:186), as the cities expand, the peri-urban well fields possibly degrade in the following ways:

- *In situ* sanitation;
- Industrial discharges;
- To a lesser degree, leaky sewers; or
- Infiltration of polluted surface watercourses in downstream areas;
- Nitrate (NO_3) or Ammonium (NH_4), increased salinity (Na + Cl);
- Elevated concentrations of dissolved organic compounds;
- Hydrocarbon petroleum; and
- Localised viruses and bacteria.

Major changes in the groundwater levels may reverse the groundwater flow directions, which could also result in the deterioration of the groundwater quality. Appleyard (1995:66) report that the changes in groundwater recharge can either directly affect groundwater quality by allowing chemicals used in urban areas to be leached into the groundwater system or indirectly by changing chemical conditions within an aquifer.

The interaction of the wastewater disposal and groundwater supply in an urban area is shown in Figure 2.4 below. The figure indicates that wastewater with as well as without treatment infiltrates the groundwater aquifer beneath an urban area.

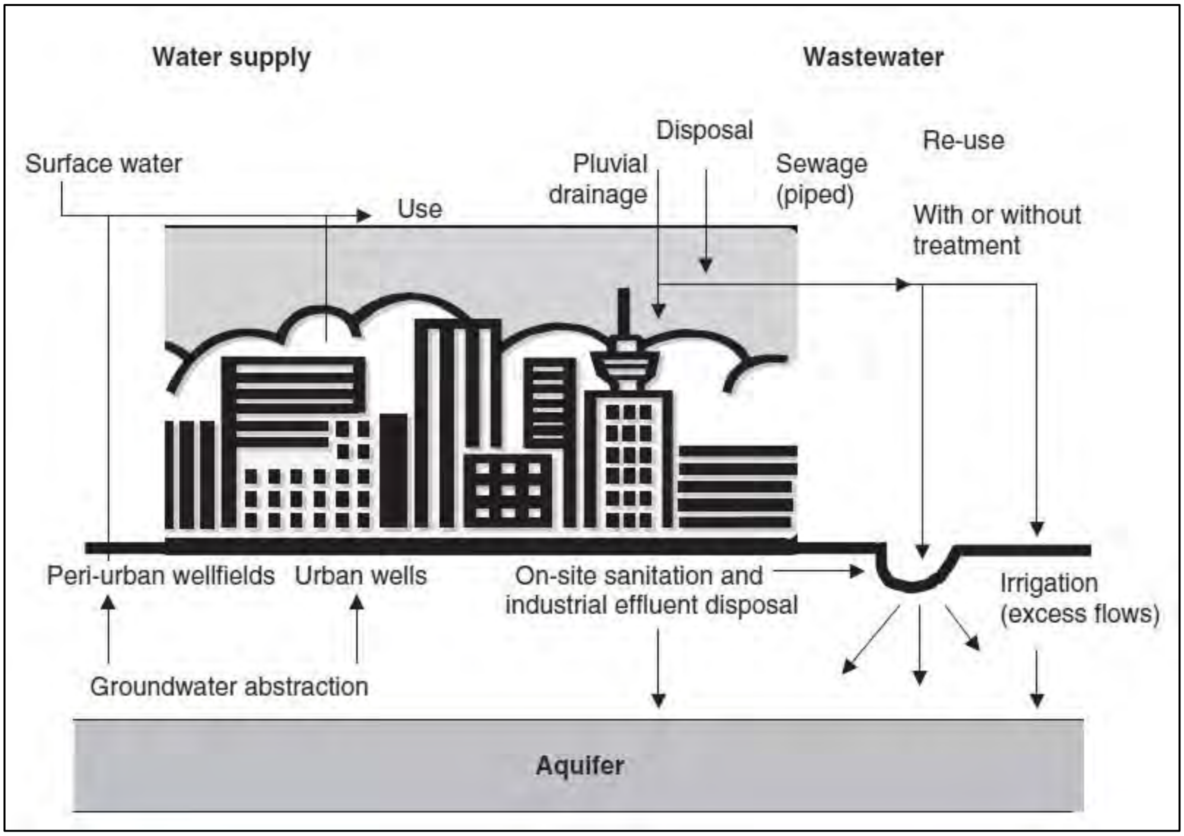

Figure 2.4: Interaction of wastewater disposal and groundwater supply (modified from Foster, 2001:186)

Appleyard (1995:186) conducted a study of urban groundwater flow in Perth, Australia. The study comprised comparative groundwater quality in three different areas namely, an undeveloped area, a new residential area (less than 20 years old) and an old residential area (more than 60 years old).

The SO_4 concentrations (according to Appleyard, 1995:65) increased with the age of the urbanised areas. The NO_3 concentrations decreased from fertiliser inputs in sewered urban areas, which indicated that denitrification was taking place.

Table 2.1 and Table 2.2 contain summaries of possible contamination sources in an urbanised area that needs to be considered, pathways in which the various contaminants can be transported as well as the receptors sensitive to the influence of the transported contaminants. The information in the Table 2.1 and Table 2.2 contains a compilation of all of the reviewed articles from Foster (1990:200; 2001:187), Lerner (1990:62; 2008:215) and Naik *et al.* (2007:345).

Common contaminant sources and prioritisation thereof (South Africa case study) is provided in Section 2.6.1.

Table 2.1: Possible contamination sources in urban areas

Industry	Common sources
Settlements and services	
Cemeteries	Graves
Wastewater treatment works	Unlined sewage sludge ponds
Industrial	
Metal plating industry	Improper treatment of disposed wastes
Industrial complexes	Production and use of hazardous chemicals
	Storage of radioactive waste materials
	Uncontrolled dumping
	Industrial emissions
	Alteration of the environment during construction
	Disposal of solid and liquid waste
	Chemical emissions from heavy industry and fanning
Refineries	Unlined effluent disposal ponds.
	Seepage from unlined slimes dams, mercury ponds and buried drums
	Leakage from the underground pipelines
	Discharged wastewater seeping into channels
Power generation	Disposal of waste ash
	Burning coal for power generation emitted into atmosphere
Transport	Spills of chemicals or fuel during transportation
	Leakage of chemical waste in underground pipelines
Petroleum	
Petrol stations	Underground fuel storage facilities in industrial premises and transport companies
Mining	
Tailings dams	Leakage from the tailings, slimes dams and waste rock dumps
Unused or abandoned mines	Waste disposal
	No more active contamination but residual contamination remains
Mining activities	Uncontrolled dumping
	Alteration of the environment during construction and mining activities
Dust	Dust from mine dumps and slimes dams

Table 2.2: Possible contamination sources in urban areas (continued)

Industry	Common sources
Waste Disposal Sites	
Hazardous waste site	Leakage or infiltration of hazardous material in unlined areas
General waste site	Leakage or infiltration of general or domestic waste in unlined areas
	Unlined general waste disposal area.
Landfill sites	Leakage of the leachate at formal landfill sites
Effluents	Liquid waste infiltrating from industrial lagoons
	Effluent irrigation on land
	Effluent discharge into rivers
Retail	
Dry cleaners, auto repair shops & printing works	Chemicals are used as solvents which can infiltrate into groundwater
Agricultural	
Agriculture	Application of inorganic fertilizers
	Soil amendment by applying sewage sludge
	Spillages of agrichemicals
Feed lots/dairies/piggeries	Storage and then disposal of faecal waste
Abattoirs	Disposal of wastewater
Urban parks/gardens	
Parks, gardens and open spaces	Wrongful irrigation with wastewater
	Peri-urban agricultural water with inclusion of fertilizers used for irrigation
Miscellaneous sources	
Automotive	Fossil fuel burning
	Spills and wash water directed to sewers or storm water drains
	Automotive manufacturing
Low Budget Homes	Burning of wood or low grade coal

Possible management options include the following:

- Comprehensive monitoring of groundwater quality and groundwater levels, especially areas close to the industrial areas;
- Proper maintenance of piped systems; and
- Implementation of abstraction restrictions in central urban areas such as parks and gardens.

2.6 Case studies

2.6.1 National (South African) case studies

According to a study conducted by the Water Research Commission (WRC, 2001), there are four (4) main sources of contamination in the groundwater of the urban areas in South Africa, which include the following industries:

- Mining;
- Industrial activities,
- Services; and
- Agriculture

The degree of potential contamination in a specific urbanised area is determined by the following factors:

- Size of the settlement;
- Density of the settlement; and
- The location of the settlement.

As the density of the settlement increases, so does the production of waste per unit area. Due to the increase in waste produced the service delivery for the removal of the waste decreases. When waste management is done correctly, the potential impacts on the underlying groundwater aquifers in an urban area will significantly decrease.

Table 2.3, derived from the WRC (2004b:36) report, shows a summary of the contamination sources and impacts identified during the investigations of a few cities in South Africa.

The South African Government has recognised the various types of possible contamination on the groundwater aquifers in the different industries and has prioritised the risk from highest to lowest risk in the following Table 2.4, which shows the industries more probable to contribute to groundwater contamination. The table indicates that on-site sanitation and agricultural activities have higher risk ratings for contamination sources than the metal and coal mining industries. Hospitals and incinerators were deemed the lowest risk as a contamination source.

Table 2.3: Summary of South African case studies

Location	Contamination Sources	Impacts
Cape Town	Cemeteries	Nutrient and bacterial contamination in groundwater.
	Wastewater treatment works	Leakage from unlined sewage sludge ponds.
	Metal plating industry	Spills or leaks from storage and production areas.
		Incorrect treatment/disposal of waste.
		Disposal ponds – unlined causing leakage.
	General and hazardous waste sites	Areas for general waste disposal – unlined.
		Disposal areas under the evaporation ponds – unlined.
	Intensive animal husbandry	Waste not managed properly.
		Too much solid waste in effluent dams causing waste slurry overflow.
	Surface-groundwater quality	Several pesticide species found in groundwater.
Durban	Industrial complex	Leakage/seepage from mercury ponds, buried drums and unlined slimes dams (containing tar and chlorinated hydrocarbons).
	Shell refinery	Spills or leaks from underground pipelines.
	Landfill sites	Leachate from hazardous as well as municipal waste sites leading to major polluting potential.
Knysna	Wood treatment plant	Leachate seepage with high concentrations of arsenic.
Johannesburg	Rehabilitated gold tailings dams	Generated acid mine drainage leakage from the tailings dams and waste rock dumps.
Free State	Petrol stations/fuel depots	Leakage from the underground storage tanks.
	Wheat-cultivated lands	Nitrogen based fertilizer released during ploughing.

Table 2.4: Prioritisation of contamination sources (modified from WRC, 2004b:67)

	National prioritisation of Contamination sources
HIGH to LOW Risk	On-site Sanitation
	Agricultural Chemicals (fertilisers, herbicides, pesticides)
	Cemeteries
	Metallurgical
	Metal (predominately gold) and coal mining
	Transport
	Petrol Service Stations (Underground Storage Tanks)
	Wood processing and preserving
	Feedlot/poultry farms
	Manufacturing - Chemicals
	Workshops (Mechanical and electrical)
	Stormwater/ sewer systems
	Automotive refinishing and repair
	Other metal product manufacturing
	Railroad yards
	Non-metallic Mineral products
	Abattoir
	Agriculture (General and crop cultivation)
	Paper/pulp industry
	Research and educational institutions
	Petroleum refining and reuse
	Solvents, chlorinated & non-chlorinated
	Munitions manufacturing
	Hazardous waste sites
	Dry cleaning activities
	General/ Domestic waste sites
	Wastewater treatment
	Textiles, Rubber and plastics
	Non-metallic Mineral products - Cement
	Leather manufacturing
	Food and beverage manufacturing
	Diamond, sand, calcrete and gravel
	Auto Salvage/Metal Recyclers
	Electrical and electrical products manufacturing
	Electricity generation
	Photographic, paint/ink manufacturing and coatings
	Pharmaceuticals and Cosmetics manufacturing
	Adhesives and sealants
	Automotive manufacturing
	Hospitals / Health Care
	Glass manufacturing
	Incinerators

2.6.2 International case studies

The principles of urban hydrogeology applied in international cities were investigated and compared. The factors considered for the comparison analysis were based on the following criteria:

- Cities or large towns with different groundwater aquifer systems in order to determine the impacts of urbanisation on each aquifer system;
- The differences in application methods between first-world and third-world countries;
- The differences in the physical properties of the hydrogeological environments; and
- The water supply dependences of each city/town, as well as the impacts on urban infrastructure.

Table 2.5 and Table 2.6 give a summary of the differences in the above-mentioned factors of each international city/town chosen for comparison. It can be seen in Table 2.5 and Table 2.6 that management methods of groundwater differ greatly in each city/town.

Table 2.5: Summary of international case studies

Factors	Japan	Thailand	Indonesia	Iran
	Tokyo (Hayashi *et al.*, 2008:3165-3172)	**Bangkok** (Onodera *et al.*, 2008: 401-410)	**Jakarta** (Onodera *et al.*, 2008:401-409)	**Shahrood** (Kazemi, 2010:150-159)
Hydraulic head (WLs)	Decline in WLs in the north due to considerable groundwater withdrawal. Rapid recovery after pumping restrictions was implemented. Gradual increase since the 1980's and stable in the central part.	Estimated to be below sea level due to prior excessive groundwater abstraction.	Relatively shallow groundwater at depths of <50 mbgl. Deep groundwater at >200 mbgl around metropolitan areas.	Rise in groundwater level to ±1 mbgl, which endangers foundations of the city. On site cesspits at depths of ±25 mbgl. Depth to groundwater ±100 mbgl. North to south groundwater flow direction. Salinity increase from north to south.
Water supply and uses	Abstraction in the north. Decline in groundwater levels in the north due to abstraction and a decline in the south due to restrictions placed on abstractions. Domestic, industrial and agricultural irrigation uses.	Not mentioned	Not mentioned	Borehole abstraction for domestic use (separate from municipal abstraction) and agricultural irrigation (fertilizers used often).
Impacts	Salinization and subsidence. Recovery of groundwater levels has affected the underground structures.	Subsidence (12 cm/year at an all-time high in 1980). Decrease in groundwater potential and contamination.	Subsidence (1-10 cm/year). Decrease in groundwater potential and contaminants found in the groundwater.	Contamination of groundwater. High concentrations of NO_3.
Mean Annual Precipitation (MAP)	1 300 mm/annum and gradual to 5 mm/a since 1960.	1 500 mm/a	2 000 mm/a due to influence of the Monsoon	154 mm/a
Evapotranspiration	649 mm/a	Not mentioned	Not mentioned	Not mentioned
Main aquifer type	Abstraction restricted to a depth of <400 mbgl, Alluvial aquifers exploited. Confined aquifers are separated by aquitards.	Mostly alluvial aquifers.	Unconfined (shallow) and confined.	Unconfined alluvial aquifers = vulnerable to contamination.

Table 2.6: Summary of international case studies (continued)

Factors	Japan	Thailand	Indonesia	Iran
	Tokyo	**Bangkok**	**Jakarta**	**Shahrood**
Groundwater flow	Regional groundwater flow as it was naturally has disappeared and local groundwater flows toward local artificial sinks have been formed.	The direction of groundwater flow is now downward and downgradient toward the coastal areas.	The direction of groundwater flow is now downward and downgradient toward the coastal areas. Flow from a north to south direction.	Not mentioned
Recharge	No recharge in city centre due to impermeable paving. Recharge takes place in new areas for development and at outskirts of city.	Not mentioned	Not mentioned	Roofs and yard runoffs are often discharged into household cesspits, which increase groundwater recharge.
Groundwater contamination	Not mentioned	Manganese and Nitrate concentrations suggest intrusion of shallow groundwater into deeper groundwater and accumulate in deeper aquifer due to the downward flow.		The maximum concentrations of Nitrate in groundwater are directly controlled by population and average rainfall/annum. Growth rate in population controls the impact of urbanization and the severity of and impact on the surrounding environment.
Groundwater potential	Stable due to restrictions on abstractions.	Decline in potential has caused the intrusion of shallow groundwater and seawater into deeper groundwater.		Not mentioned

2.7 Applied modelling tools

2.7.1 Conceptual modelling

A conceptual model is a simplified representation of the physical environment as viewed by the hydrogeologist. The conceptual model aims to quantify all geological, hydrological and hydrogeological interactions of the natural system that may be presented as mathematical input into a numerical model (Betancur *et al*., 2012:203). The conceptual model simply describes how groundwater enters an aquifer system, flows through an aquifer and exits it (Rushton, 2003:xiii). It can also include the expected impacts and risks as understood by the conceptual modeller.

The process through which a conceptual model is constructed is described in Figure 2.5.

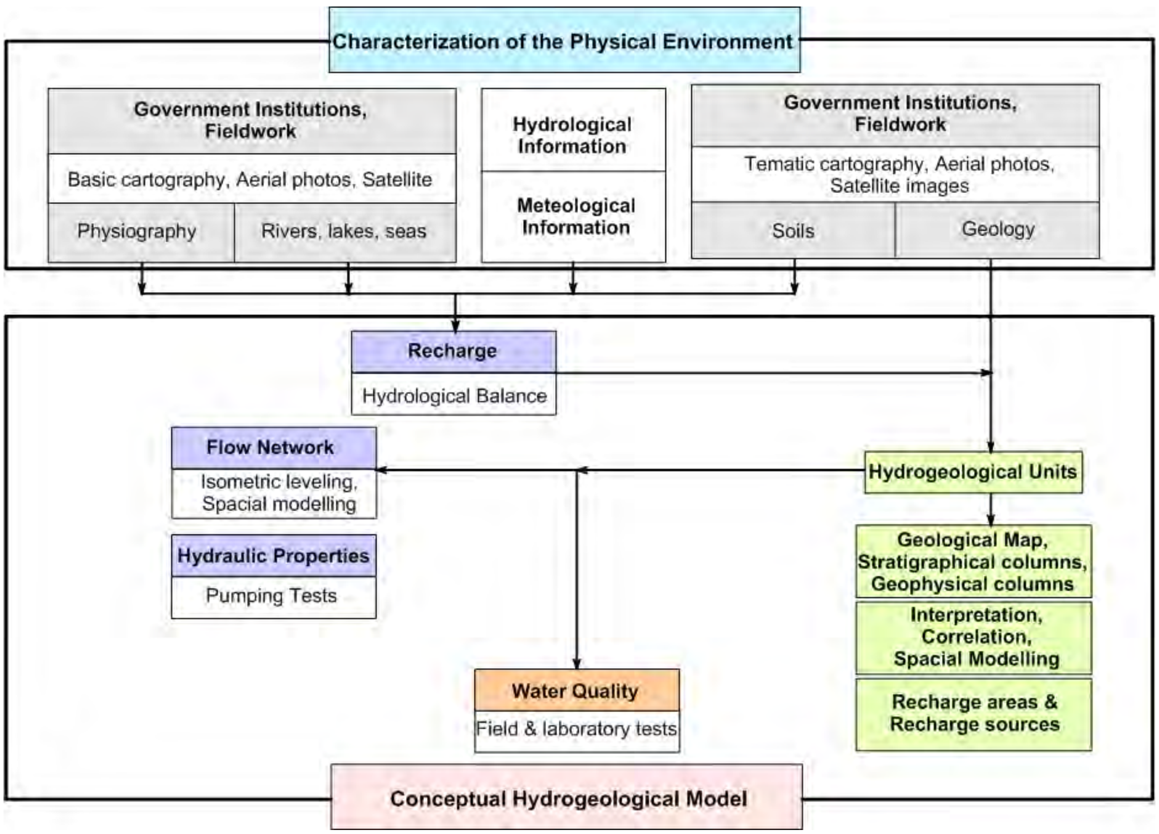

Figure 2.5: Conceptual modelling methodology (modified from Betancur *et al*., 2012:206)

The conceptual model for the study area (Section 4.8) aims to describe topographic, hydrological, geological and hydrogeological environments and quantify their interactions. All regional and site-specific data were obtained and transformed into simplified concepts in order for the system to be represented in the modelling environment (ASTM, 2010:2). This is a critical step for any modelling to continue.

All available hydrogeological data (either gathered in the field or obtained from existing sources) for a study area are taken and analysed for the formulation of the conceptual model such as aquifer description, recharge, spatial relation between aquifers, aquifer thickness, general geology (generally deduced from local boreholes), stratigraphical units, groundwater levels and flow directions. The data components are all interpreted into a working description of the characteristics and dynamics of the physical hydrogeological environment (NWU, 2012a).

According to Rushton (2003:2), the construction of a conceptual model often starts with elementary sketches or geological cross sections and can evolve into complex and detailed three-dimensional diagrams as more information about the site becomes known.

2.7.2 Modelling

Modelling is a simplification of the natural environment and cannot simulate the intricacies of the groundwater system in detail. It should be seen as an approximation and the quality of the input data will determine the quality of the output information. Therefore, modelling will always have inaccuracies due to the uncertainty in data, the capabilities/limitations of modelling code to describe the natural processes and the factors selected by the modeller to resolve the non-unique solution.

When constructing a model, it is critical to first define the purpose and objectives of the task (i.e. problem statement). Common groundwater problems are listed in order of increasing complexity (Haitjema 1995:245):

- Illustration of known groundwater flow principles;
- Determination of aquifer parameters;
- Determination of hydrogeological conditions;
- Determination of groundwater flow history;
- Prediction of future groundwater flow patterns;
- Prediction of future contaminant movement; and
- Basic research on flow or transport phenomena.

James & Read (2010:2) suggest that an analytical solution refers to any differential equation which could be evaluated to any degree of desired accuracy without modifying the structure of the solution at any given point in time and space.

In general, an analytical model is a tool in which a quick preliminary evaluation of the groundwater system can be performed. It also enables the analysis of any groundwater contamination as well as to conduct a sensitivity analysis with minimalistic data. An analytical model relies on the assumptions from professionals with sound judgement and experience in order to obtain an analytical solution. Although analytical models can provide rapid and inexpensive solutions to hydrogeological problems, they are limited to ideal cases (NWU, 2012a).

Computations of numerical models are based on differential groundwater flow equations which are solved by using numerical analysis methods, i.e. numerical groundwater models. The data used for input into the modelling system combined with the governing equations determine the behaviour of a groundwater system under the specified conditions (WSTB, 1990:52).

The differences in some of the modelling techniques considered in this dissertation are summarised in Table 2.7. The table was compiled using different sources (Haitjema, 1995:203-205; Fetter, 2000:519-527; NWU, 2012a) of information that considers the differences between the different modelling methods.

Table 2.7: Differences between the modelling methods (information from Haitjema, 1995; Fetter, 2000; NWU, 2012a)

Factors	Finite Difference	Finite Element	Analytical Element
Gridding	Regular grid with mesh-centred nodes. The newest version of Modflow (2014) is complete with an irregular grid, which provides more flexibility to the calculations between cells.	Mesh with triangular nodes.	Grid and mesh independent and does not rely on discretization of the flow domain, which eliminates the compromise between model resolution and size of the model area.
Boundaries	Boundary conditions must be specified.	More flexible domain but the boundary conditions must also be specified.	Method not constrained by aquifer boundaries, which allows examination of groundwater at regional as well as a more detailed local scale.
Model construction	Due to the need for data and boundary confinements, changes are not easy because the representation of the flow system must be reconstructed each time.	Due to the need for data and boundary confinements, changes are not easy because the representation of the flow system must be reconstructed each time.	Time and money can be saved when the model domain must be expanded or the model must be modified.
Data entry	Easy data entry	Difficult data input depending on the user's experience.	Gradual, stepwise data input to the degree of necessity is required. This method can reduce expensive unnecessary additional field data acquisition.
Accuracy	Mathematically not too complex, resulting in low accuracy for some problems.	Mathematically very complex, resulting in high accuracy possible.	The quality of a model is measured by the degree of complexity and detail of the model and model input data.
Assumptions	More data unknowns, more assumptions must be made increasing risk of the model collapsing under the pressure of suspicion.	If there are more data unknowns for a site, more assumptions must be made in the model construction phase, which increases the risk of model integrity and accuracy.	This method places the responsibility of the outcome with the user due to the absence of assumptions.
Requirements	Need field data	Need field data	AEM is less sensitive to aquifer parameter inaccuracies.

2.8 Risk assessments

2.8.1 Preface

Risk assessment is essential in the decision-making processes regarding the quantification of effects of human activities on the surrounding environment (Darbra *et al*., 2008:377). However, in every decision-making process, several factors remain uncertain and questions around accuracy of data are one of the associated factors.

Uncertainty in risk assessments has two origins, which are the following:

- Randomness; and
- Incompleteness.

Several techniques are available in order to address these factors of uncertainty, namely:

- The environmental risk assessment methodology, which is based on the expected risk of a site and the author's experience with similar conditions;
- The fuzzy logic method, which uses mathematical parameters to verbalise environmental issues; and
- The DRASTIC approach, which comprises a numerical indexing system and incorporates the geological as well as hydrogeological factors from which the aquifer vulnerability of an area can be calculated.

A risk is generally defined as a combination of hazards and vulnerability. A hazard represents a potential harmful event and given environmental factors in the given area at the specific time. Vulnerability shows the degree of weakness at a specific time in the system.

Part of the risk assessment is to estimate the possibility of a particular event occurring under certain circumstances.

Risk management, however, indicates the implementation of the identified risks during the risk assessment for the protection of public health and environmental resources.

Darbra *et al*. (2008:378) state that the risk assessment part of a study could be considered to form the most important step in the risk-management process. It is also important to note that the two are interlinked, as described in Figure 2.6 below.

Figure 2.6 describes the overall steps in risk management in lining the risk assessment process, which in turn forms part of the risk management process.

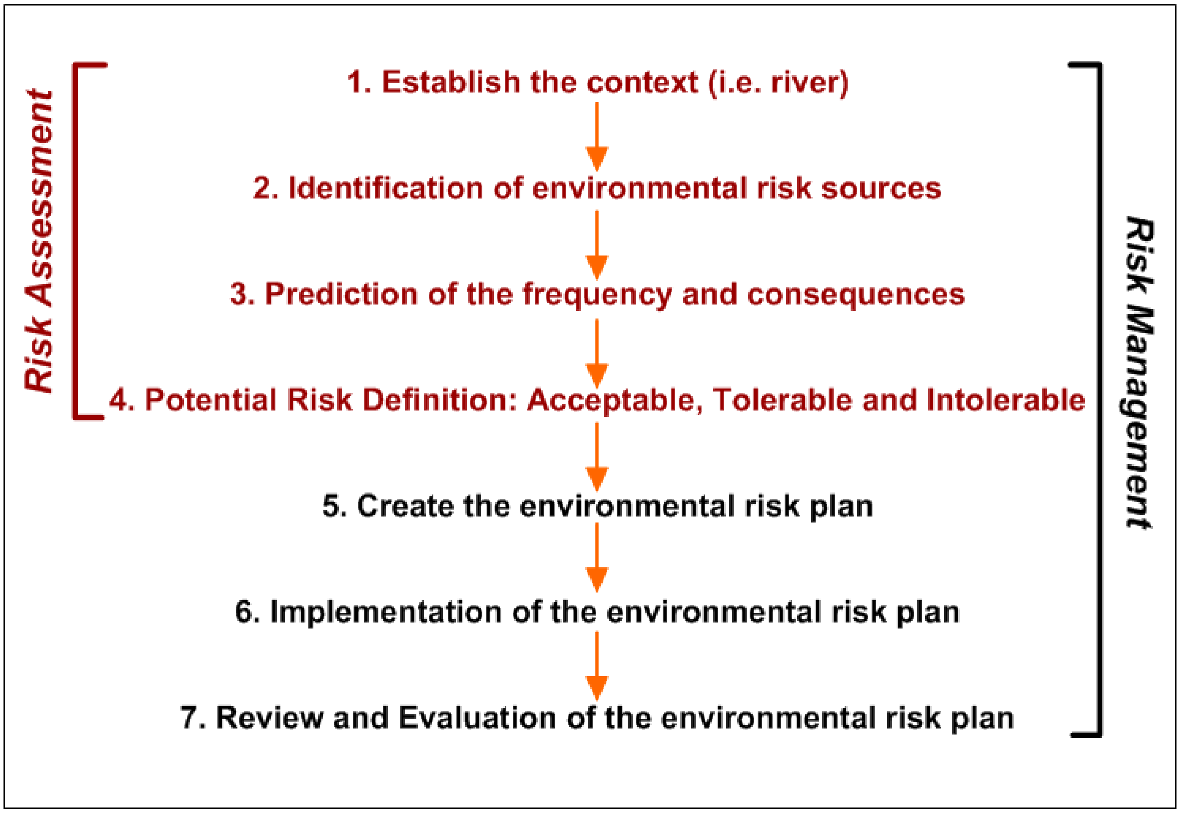

Figure 2.6: Steps in risk management (modified from Darbra *et al*., 2008:378)

2.8.2 Environmental risk assessment method

The environmental risk assessment method involves the identification of possible impacts on the environment. It is based on a rating system derived from Plomp (cited by AGES, 2013:24). The system can also be adapted to fit different processes and site-specific conditions.

The method not only quantifies the risks on the environment through anthropogenic factors, for example: mining activities, industrial and agriculture, but also incorporates the identification of a variety of possible environmental impacts. This method also incorporates the following components in which a standardised assessment is used in order for the impacts to be identified and for each component to be comparable:

- Geology;
- Topography;
- Climate;
- Soil;
- Land use;
- Biodiversity;
- Surface water;

- Groundwater;
- Air quality;
- Noise;
- Cultural significance; and
- Socio-economic.

It must however be noted that in a specialist groundwater assessment, only parameters relevant to groundwater will be included.

Each impact identified has a significance rating prior to and with mitigation. The identification of possible impacts is assessed according to the following criteria:

- Probability (likelihood of impact occurrence);
- Scale (spatial extent of the impact effect);
- Magnitude of the impact (low, medium or high); and
- Duration (how long will the possible impact last).

The criteria mentioned above are assigned a weighting value in which a significance rating is obtained for each of the environmental components. Table 2.8 describes how the weighting values are assigned to each evaluation method in order to obtain a significance value. The significance value of each impact is described prior to management measures and with management measures.

Table 2.8: Environmental risk assessment criteria and weighting (modified from GCS, 2014)

Magnitude (M)		Duration (D)	
Weighting	***Description***	***Weighting***	***Description***
0	None	0	None
2	Minor (No measurable change)	1	Immediate
4	Low (Slight measurable)	2	Short-term (0-5 years)
6	Moderate (Measurable)	3	Medium-term (5-15 years)
8	High (Measurable)	4	Long-term (ceases with the operational life)
10	Very high / don't know (Level is too high to measure)	5	Permanent
Scale (S)		**Probability (P)**	
Weighting	***Description***	***Weighting***	***Description***
0	None	0	None
1	Site only	1	Improbable
2	Local	2	Low probability
3	Regional	3	Medium probability
4	National	4	Highly probable
5	International	5	Definite/don't know

Status of Impact
+: Positive (A benefit to the receiving environment)
N: Neutral (No cost or benefit to the receiving environment)
-: Negative (A cost to the receiving environment)

In order to calculate the environmental significance for each of the ranked factors, the following formula is used:

SP = (magnitude + duration + scale) x probability

Where:

SP indicates the Significance Points for the ranking system.

The maximum value of significance points that can be achieved is 100. Whether the impact status is either positive or negative, the total calculated significance points are ranked from low to high risk based on the colour codes as described in Table 2.9 below.

Table 2.9: Environmental risk rating (modified from GCS, 2014)

Significance	*Environmental significance points*	*Colour code*
High (positive)	> 60	H
Medium (positive)	30 to 60	M
Low (positive)	0 to 30	L
Neutral	0	N
Low (negative)	0 to 30	L
Medium (negative)	30 to 60	M
High (negative)	> 60	H

2.8.3 Fuzzy logic

The fuzzy logic approach uses membership functions and linguistic parameters to verbalise environmental issues. This approach is used as a mathematical tool in order to model real world inaccuracies and uncertainties.

Pokoràdi, (2002:63) state that fuzzy logic is an approach in which a set of variables (that can have degrees of truthfulness and falsehoods) are represented by value ranges from 0 (false) to 1 (true). The outcomes of a fuzzy logic operation are expressed as probabilities rather than certainties.

Where there is a lack of knowledge or an absence of precise data, the fuzzy logic system considers only the cause-and-effect relationships within the variables. The capability also includes assessment of the degree of risk exposure, ranks the key risks consistently and considers only the available data and experts' opinions (Shang & Hossen, 2013:3).

The fuzzy logic (Figure 2.7) process includes the following sub-processes:

- Fuzzification;
- Interference;
- Composition; and
- Defuzzification.

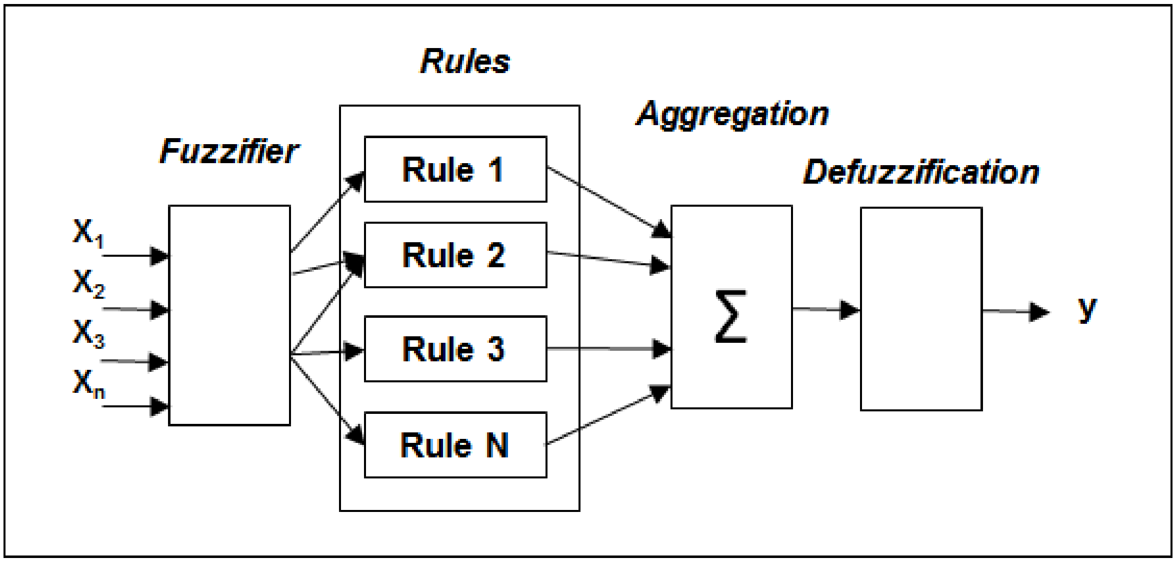

Figure 2.7: Fuzzification process summary (modified from NWU, 2012b)

As the fuzzy logic process is expressed as probabilities, the categories include frequent, likely, occasional, seldom and unlikely. The probabilities are then combined with severity categories (catastrophic, critical, moderate and negligible) in order to establish a risk assessment matrix (Pokoràdi, 2002:66).

The fuzzy logic rule set is used in conjunction with weighted averages derived from the risk assessment matrix are then used in the application of the following equation:

$$\%\ Risk = \frac{\sum_{i=1}^{n} Wi * \mu(Wi)}{\sum_{i=1}^{n} \mu(Wi)} * 100$$

Where:

n = number of rules

μWi = minimum degree of membership for rule i

Wi= weight of rule i

The fuzzy logic approach to risk assessments is used in a wide variety of different fields (i.e. economic, environmental, etc.) in order to rule out human error in the decision-making processes.

2.8.3.1 Urban risk assessment (URA)

A report on groundwater sources and contaminants in urban catchments of South Africa was researched in a collaborative effort between the Council for Scientific and Industrial Research (CSIR), Institute for Groundwater Studies (IGS) and the University of the Western Cape (UWC) and was published by the Water Research Commission (WRC) in 2004.

Inorganic and organic contaminants as well as their associated sources within the urban catchments were identified and a data information system based on the fuzzy logic methodology was developed as a tool to quantify the risks of contamination in urbanised areas.

Unlike the prioritisation methods, a risk analysis provides an approximate likelihood of a contamination occurrence and taking the hydrogeological environment as well as the contamination sources into account (WRC, 2004a:61).

A tiered approach was followed during the development phase of the tool and the following levels are generally followed when conducting a risk assessment:

- Level 0: It requires minimal data, it is based on a rating system, it is quick to perform and the results have a low confidence level;
- Level 1: It refers to the assessment of contaminants on a local scale; and
- Level 2: Comprises a more comprehensive assessment (i.e. commonly includes data collection) and the results have a medium to high confidence level.

The tiers are dependent on data availability and the first- and second-level tiers are based on the fuzzy logic methodology. Figure 2.8 presents the building blocks on which the URA tool functions. It graphically represents the stepwise procedures for each level of evaluation and it is preceded by the national rankings of sources and contaminants based on a weighting system.

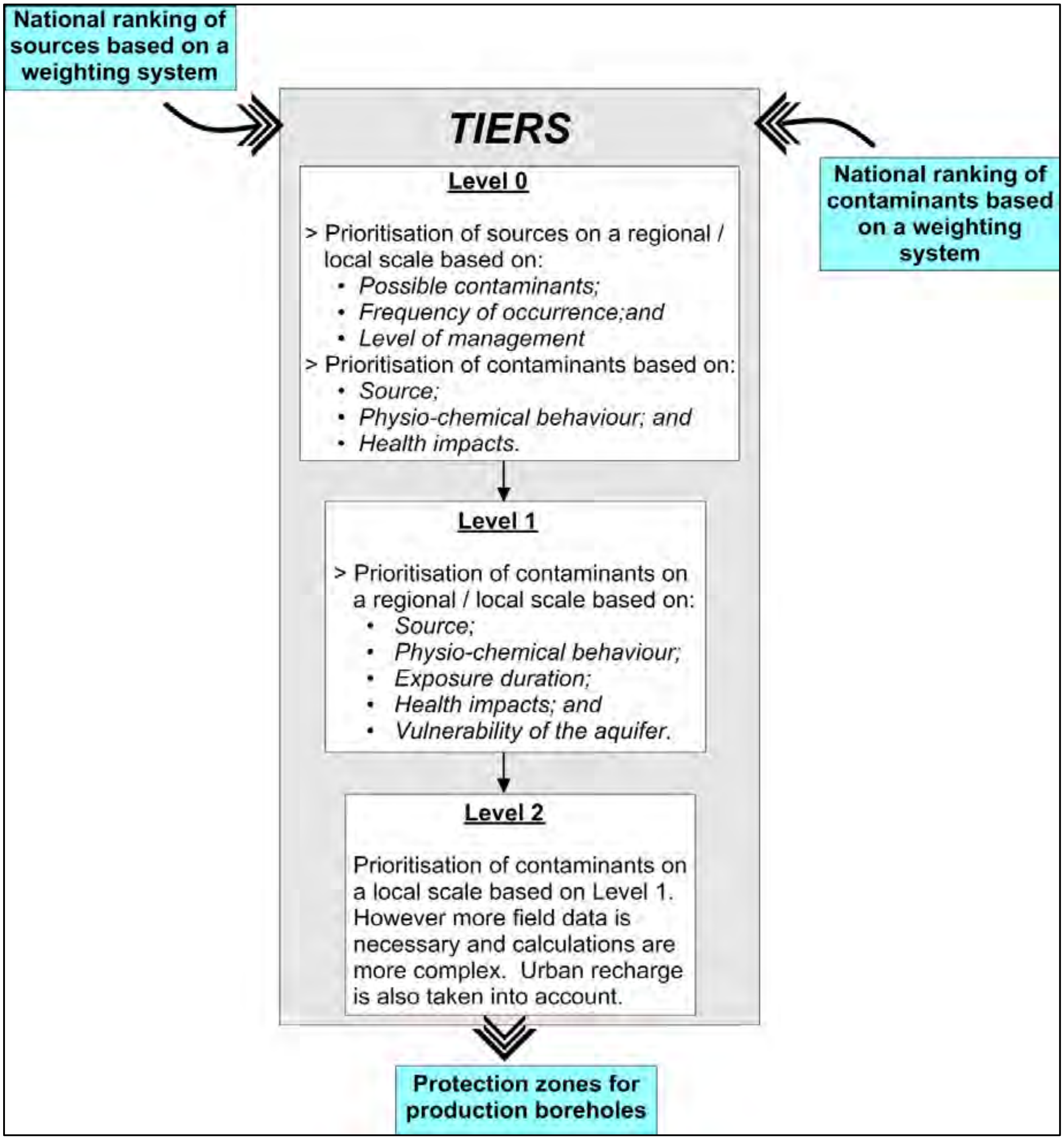

Figure 2.8: Tiered approach to South African urban risk prioritisation methodology (modified from WRC, 2004a:64)

In order to ensure validity of the output results in the URA tool, several factors had to be taken into account in order to quantify the urban risks for each urbanised area properly, depending on the source as well as the expected contaminants within the source area. The factors include the following:

- Exposure or contact with the contaminant (frequency, magnitude and duration – based on environmental impact principles);

- Aquifer vulnerability (based on DRASTIC risk assessment approach principles, further discussed in Section 0);
- Health risks and effects;
- Contaminant sources; and
- Physio-chemical properties of the identified contaminants.

2.8.4 DRASTIC Approach

Aller *et al*. (1987:1) indicate that the DRASTIC method was developed in order to quantify potential contamination in any hydrogeological setting.

The DRASTIC approach comprises an indexing system of numerical ranking in order to calculate aquifer vulnerability and incorporates the major geological and hydrogeological factors.

The geological and hydrogeological settings form the basis of understanding the aquifer system and identifying which major factors can control and contribute to possible contamination.

The DRASTIC method makes use of seven (7) factors to calculate the vulnerability index value (Aller *et al*. 1987:17):

- Depth to groundwater (D) – determines the maximum distance contaminants travel before reaching the aquifer;
- Net recharge (R) – the amount of water that is able to travel from ground surface to the water table;
- Aquifer (A) – the composition of the aquifer material;
- Soil media (S) – the uppermost portion of the unsaturated zone;
- Topography (T) – the slope of the ground surface;
- Impact of vadose zone (I) – the type of material present between the bottom of the soil zone and water table; and
- Hydraulic conductivity of the aquifer (C) – indicates the aquifer's ability to allow for the flow of water to occur.

In the South African environment, "C" is often highly variable due to the fractured nature of most of the aquifers present; thus the DRASTIC approach can be modified to the DRASTI approach (WRC, 1995:7; WRC, 1998:5). The definition of the DRASTI index is shown below.

$$DVI = Dw.Dr + Rw.Rr + Aw.Ar + Sw.Sr + Tw.Tr + Iw.Ir$$

Where:

DVI is the DRASTI Vulnerability Index;

Dr, Ar, Sr, Tr and Ir are the numerical values assigned to each factor; and

Dw, Aw, Sw, Tw and Iw are the numerical weighting values assigned to each factor.

It is important to note that the DRASTI methodology does not supply quantitative values, but rather relative values, i.e. the method must be applied to see which aquifer in a region is most susceptible to contamination.

Some of the assumptions for the DRASTI methodology described by Yang & Wang (2010:4) include the following:

- The contaminant is introduced at the ground surface;
- The contaminant is flushed into the groundwater by precipitation (recharge);
- The contaminant is soluble; and
- The area assessed using DRASTI must be 0.4 km^2 or larger.

CHAPTER 3

3 METHODOLOGY

3.1 Conceptualisation of the groundwater system

3.1.1 Preface

The first principles of hydrogeology involves the conceptualisation of the hydrogeological system through the literature review of existing information on solving a problem and the investigation of any impacts related to environmental change over time. Qualitative impact and risk assessments are conducted in order to detect any changes in the environment from available data sets. The conceptualisation is tested with appropriate modelling.

The sections that follow will discuss the development of the conceptualisation for the site-specific case study.

In order to quantify the risks of urbanisation successfully, a large dataset is required with various components of the site such as the following:

- All groundwater and surface water data (i.e. all available groundwater levels, borehole locality and depths, groundwater and surface water quality, borehole yields, river flow gauge chemistry, river flow volumes and rainfall data);
- Infrastructural data with development plans and implementation dates (site specific);
- Depths of underground systems (sewage systems, pipelines, depth of underground parkades, discharge points or sumps to give an indication of how much water is discharged per day);
- Infrastructural management (maintenance);
- Constant (monthly) input and output measurements in order to determine leakage volumes (monitoring); and
- Information on pre-urbanisation conditions.

These large datasets are often non-existent or not available to the public, resulting in incomplete or unreliable studies, as many assumptions on estimated parameters must be counterbalanced due to the lack of data.

3.1.2 Data sources, collation and methods/procedures

Potchefstroom, located in the North-West Province, was used as a case study and the history of water use, urbanisation and infrastructural growth were evaluated in order to achieve the objective of this study.

Relevant documentation from the Tlokwe Local Municipality and documentation of previous studies done in the Potchefstroom area were collected and only applicable and useable data were collated and added to this study.

Open source information was gathered in order to conduct the study, as more specialised information could not be made available due to confidentiality agreements with the parties.

Relevant public domain data sets including all available documentation were reviewed including, but not limited to all geological, hydrogeological and climatic information which was included in general site maps.

The following relevant open source data sets were used for review:

- 1:250 000 Geological Map 2626: West Rand, Council for Geoscience;
- 1:50 000 Topographical map sheets;
- The groundwater resources of the Republic of South Africa, sheets 1 and 2 (Vegter 1995);
- GRDM, Groundwater Resource Directed Measures, GRDM Training Manual; and
- The National Groundwater Archive (NGA) and Water Authorisation Registration Management System (WARMS) from the Department of Water Affairs (DWA).

3.1.2.1 Groundwater level data

The groundwater level data comprised the following:

- Groundwater level data (time series and non-time series) as well as geological data were collected from the NGA. The groundwater levels were also correlated based on the geology of the borehole localities. This is correlated in order to determine the nature of the aquifer system in the area; and
- Time series groundwater quality data sets (where available) were assessed.

Grid files were extracted from a 50 m resolution digital terrain model (DTM) in Global Mapper v. 14 and an interpolation program (Tripol) was used as the Bayesian interpolation tool (for groundwater levels in aquifers that showed a correlation to surface elevations). A groundwater contour map was generated for the area.

3.1.2.2 Hydrochemistry Data

Historical surface-water monitoring-points hydrochemistry from Tlokwe Local Municipality was acquired, processed and interpreted. Upstream and downstream flow gauge chemistry was acquired from the NWU consolidated river chemistry database and processed in Excel 2010.

Groundwater chemistry was downloaded and assessed for four (4) boreholes (ZQMVFD1, ZQMVFD2, ZQMVFD3 and ZQMPFM1) from DWA.

All the hydrochemistry data were plotted to produce groundwater Piper and Durov diagrams to understand the groundwater characteristics of the area.

The analytical results were compared to the Department of Water Affairs South African Water Quality Guidelines for Domestic Use Target Values (DWA SAWQTV 1996:1-166) and South Africa National Standard (SANS 241-1: 2011) drinking water standard in order to evaluate the groundwater quality.

3.1.2.3 Geology

A conceptual cross-section was constructed using the geological data from the NGA. Fault lines digitised from the geological map were also used and incorporated into the cross-section. A topographical grid for the site area was created to generate a three dimensional map.

3.1.3 Conceptual modelling

The data incorporated into the conceptual model, as suggested in in Mandle, (2002:12) and ASTM, (2010:2), were as follows:

- The regional and site-specific geological framework, where lateral aquifer extents, aquifer thicknesses, geological structures, confining layers lithology unit continuity are described and quantified;
- Topographic data for the model domain, including the elevation and extent of surface water bodies;
- Hydraulic properties for the system, such as transmissivity and recharge rates;
- Sources and sinks to the groundwater system, for example, abstraction boreholes, evaporation and gaining streams (sinks), and losing surface water bodies (source); and
- Spatial and temporal trends in hydraulic heads.

It should be noted that no additional groundwater field investigations were completed during this study to specifically demonstrate the reliability and integrity of open source data.

3.1.3.1 Source

Some of the major urban contamination contributions were established including:

- Mining;
- Agriculture;
- Petrol, diesel and transport services;
- Industrial activities (factories, tannery, abattoir, brewery, and railway station); and
- Cemeteries; and
- Pit latrines/septic tanks.

Potchefstroom has a long history with active mining in the immediate and extended areas around the town. Coetzee *et al*. (2006:iii) report that large volumes of water from the underground mine workings are discharged back to the Wonderfontein Spruit via canals and pipelines, while intercepted groundwater is transported across the catchment into the adjacent catchments.

The discharged water comprises increased sediment loads and contaminant contamination (i.e. sulphate and heavy metals, including uranium) into the receiving water bodies. Potchefstroom is vulnerable to this contamination.

Farming activities in the surrounding Potchefstroom area also have an impact on the groundwater qualities. Farming activities also make use of fertilisers and pesticides which causes increases in (for example nitrate concentrations) in groundwater systems.

Hydrocarbon contamination (for example petrol and diesel) is common within urbanised areas as leaking underground storage tanks are a source of contamination. The industrial area is located immediately adjacent to highly dense residential areas to the west and north and poses a high risk of potential contamination. Leakage of the storage tanks may filter directly into the upper shallow weathered aquifer.

3.1.3.2 Pathway

The different aquifer systems do not necessarily occur in isolation of one another. It must further be noted that the dolomitic aquifer is likely to remain the aquifer of concern as it display karstic characteristics.

The surrounding river systems also act as potential pathways for contamination, especially where groundwater-surface water occurs. Contaminated water may enter the streams/river and be transported to downstream receptors.

3.1.3.3 Receptor

Domestic and other supply boreholes and downstream water systems are considered sensitive receptors. Previous studies (Durand, 2012:27; Barnard *et al*., 2013:656; Nel *et al*., 1939:15; Brink *et al*., 2000:99; Reimhold & Gibson, 1996:134) have found that preferential flow paths along geological lineaments (e.g. faults) related to fracturing is significant in the area.

3.1.4 Qualitative risk assessment

The geological and hydrogeological settings form the basis of understanding the aquifer system of a project area and identifying which major factors can control and contribute to possible contamination is essential.

Different risk assessment approaches will be tested and compared in order to determine the risks associated with urbanisation. The risk methodologies to be compared are the following:

- Environmental Risk Assessment;
- Fuzzy Logic; and
- The DRASTIC method.

3.2 Modelling tools

In order to test the conceptual model for the case study area, the analytic element method (AEM) modelling with the use of the Visual AEM program was envisaged as an appropriate tool, due to the simplicity of the program and modelling method. In addition, the finite difference modelling method with the use of Processing Modflow (PMWin) was thought to be used to compare the results obtained from the AEM method to ensure similarity. The development of an adapted analytical model is the third option.

3.3 Quantification of urban risk

After the numerical modelling phase, a detailed risk assessment will be completed following the findings of the model. The risks identified during the modelling will be discussed and the appropriate tool will once again be selected in order for the risks to be quantified.

3.4 Urbanisation hydrogeology risk methodology

Through the use of all the acquired knowledge on the study area a logical stepwise process will be followed in order to develop a methodology to quantify the risks for urbanisation in subsequent study areas and also assist the hydrogeologist during the decision-making processes.

CHAPTER 4

4 CASE STUDY: POTCHEFSTROOM (SOUTH AFRICA)

4.1 Preface

Potchefstroom was selected for the case study due to its long history of active mining in the immediate and extended area around the town. The findings will be discussed in the following sections.

4.2 Study area

4.2.1 Location

The town of Potchefstroom is located approximately 120 km west-southwest of Johannesburg and is bisected by the N12 route. Potchefstroom is located immediately north of the Vredefort Dome, a World Heritage Site for the largest and oldest meteorite impact craters in the world.

The local municipality of Potchefstroom is known as the Tlokwe Local Municipality and forms part of the Dr Kenneth Kaunda District Municipality.

Figure 4.1 provides a general locality map for the study area.

4.2.2 Climate & topography

According to Vegter (cited by DWA, 2006a:4), Potchefstroom is situated in a summer rainfall area and the climatic conditions vary significantly from west to east across the Province where the mean temperatures between the warmest and coldest months range between 12 °C and 15 °C. The mean annual precipitation (MAP) for the combined catchment areas accounts to 607.3 mm/a, with rainfall predominantly occurring in the summer months from October to May.

Figure 4.2 shows a graphical representation of the rainfall data.

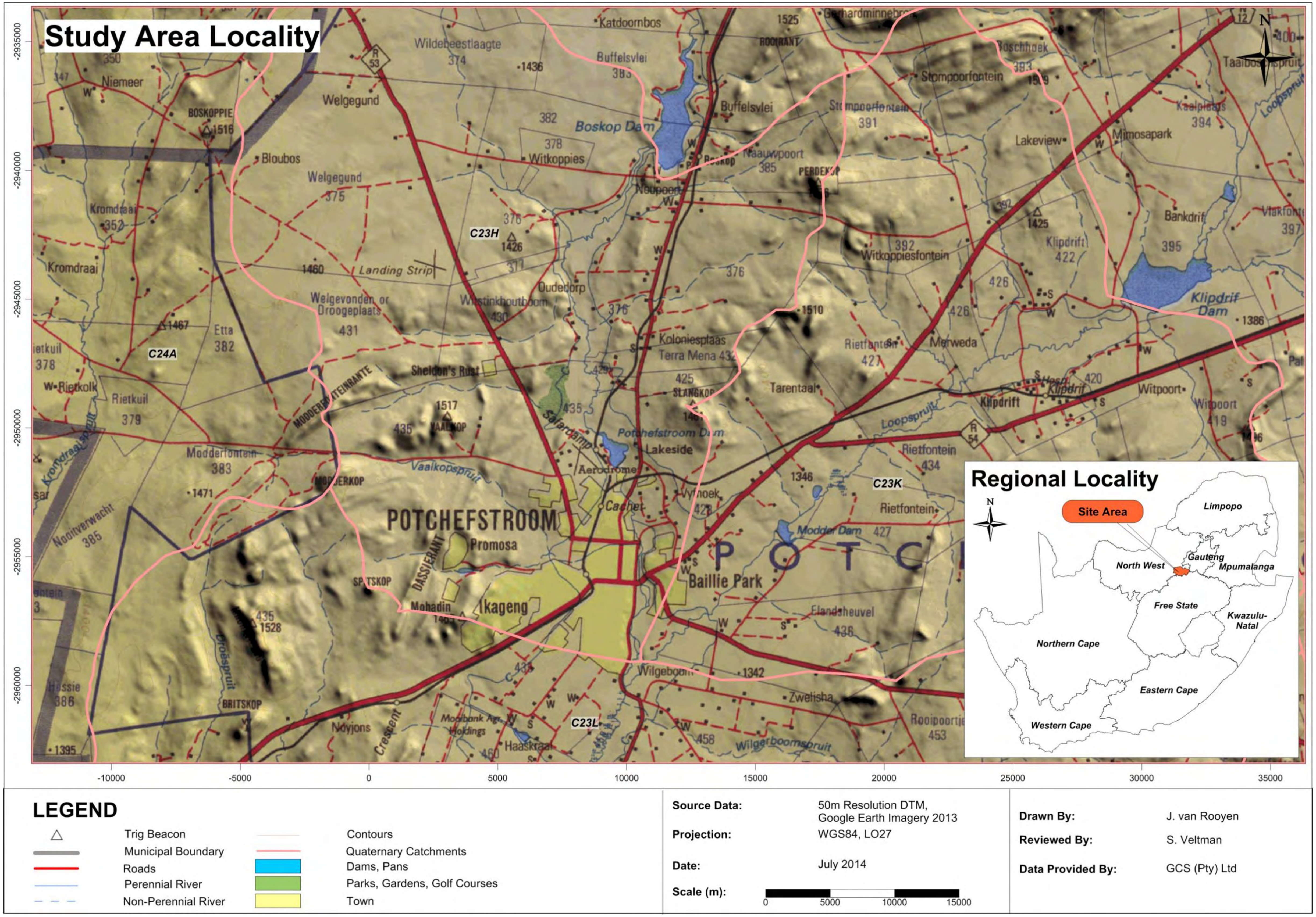

Figure 4.1: Site locality

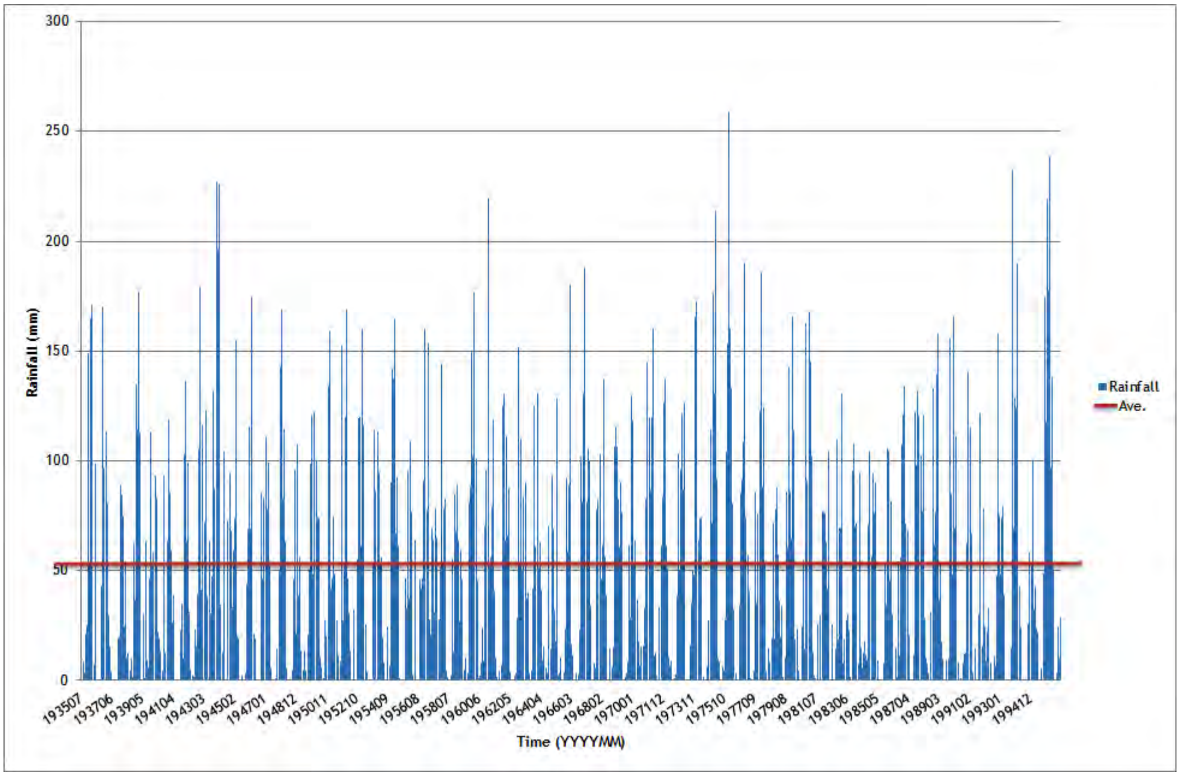

Figure 4.2: Time series rainfall graph

The study area is located in the Upper Vaal Water Management Area (WMA). The site is partly situated in the C23H quaternary catchment, with the southern and eastern part of the town situated in the C23L and C23K quaternary catchments, respectively.

The topography of the area, from north to south, ranges between 1 390 and 1 340 metres above mean sea level (mamsl). From west to east, the topography ranges between 1 450 and 1 355 mamsl. The Mooi River is a perennial river that runs through the town of Potchefstroom and flows in a southerly direction.

4.3 Water sources of Potchefstroom

According to Annandale & Nealer (2011:111), the Mooi River valley has always been referred to as a ‘water-rich area’. Most of the potable water supply for Potchefstroom is gathered from the surface- with some coming from groundwater.

Annandale & Nealer (2011:112) reports that the town of Potchefstroom is located downstream of an environmental disaster due to acid mine drainage (AMD), due to a direct result of gold mining (upstream) impacting negatively on the Wonderfontein Spruit, a tributary of the Mooi River. Due to this negative impact, not only the surface water will be impacted, but also the groundwater and springs.

Water is stored in the Klerkskraal Dam, Boskop Dam and the Potchefstroom Dam (hereafter referred to as Potch Dam).

4.3.1 Water requirements

The water requirement calculation for Potchefstroom has been compiled from DWA (2011:15). Table 4.1 describes the amount of water consumption per person per day and Table 4.2 provides the percentage (%) of population in each dwelling type.

Table 4.1: Water use categories (DWA, 2011:15)

Category	Dwelling type		Average water consumption
			l/capita/day
1	Flats		226
2	Clusters		255
3	Single residential	Low income	101
4		Medium income	189
5		High income	304
6		Very high income	442
7	Informal	RDP level	40
8		No services	12

Table 4.2: Percentage population per category (DWA, 2011:15)

Category	Dwelling type		% Population per category		
1	Flats		3.8	70.6	Formal
2	Clusters		1.1		
3	Single residential	Low income	43.1		
4		Medium income	17		
5		High income	5.4		
6		Very high income	0.1		
7	Informal	RDP level	29.4	29.4	Informal
8		No services	0		

According to the DWA (2011:17), 60% of the population falls in category 3 and 4 and 29.4% falls in category 7 and 8 in the town of Potchefstroom. These calculations were based on the year 2008 figures, where the total amount of water used in that year amounted to 18,542 million m^3/a.

Additional information regarding the growth of the town of Potchefstroom was collected from the South African rural development and land reform database (SPISYS) and graphically presented in Figure 4.3 to Figure 4.5. The figures compiled consist of topographical images from 1940 to 1990. The images were captured on the same scale in order to observe the urban changes. In the image dated to 1960. It is evident that the Ikageng residential area started development on the western part of the town. It is clear the town has significantly grown over time, not only residentially, but also industrially. In addition to the urban growth, several parks and gardens have made an appearance from 1990.

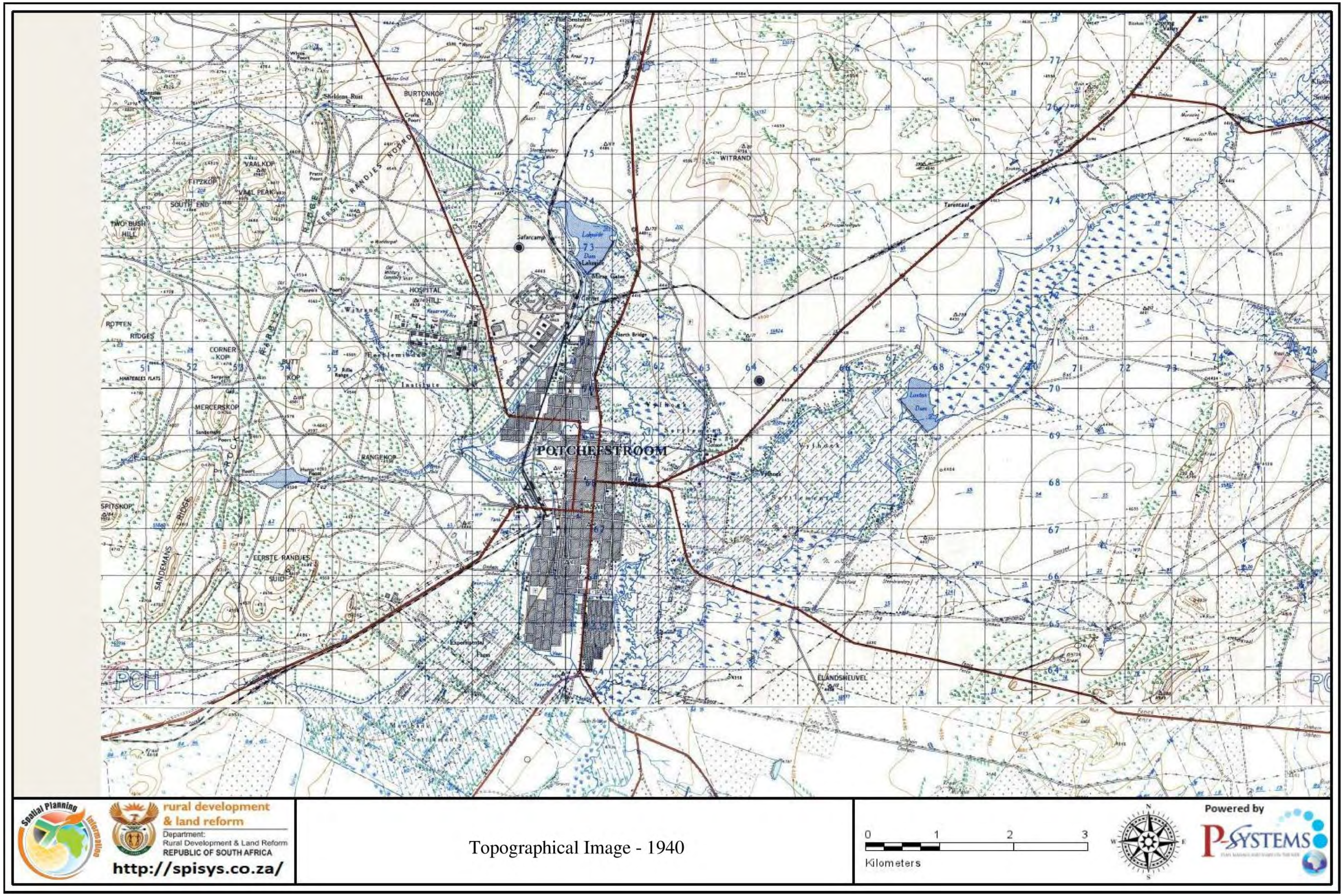

Figure 4.3: Topographical change – 1940

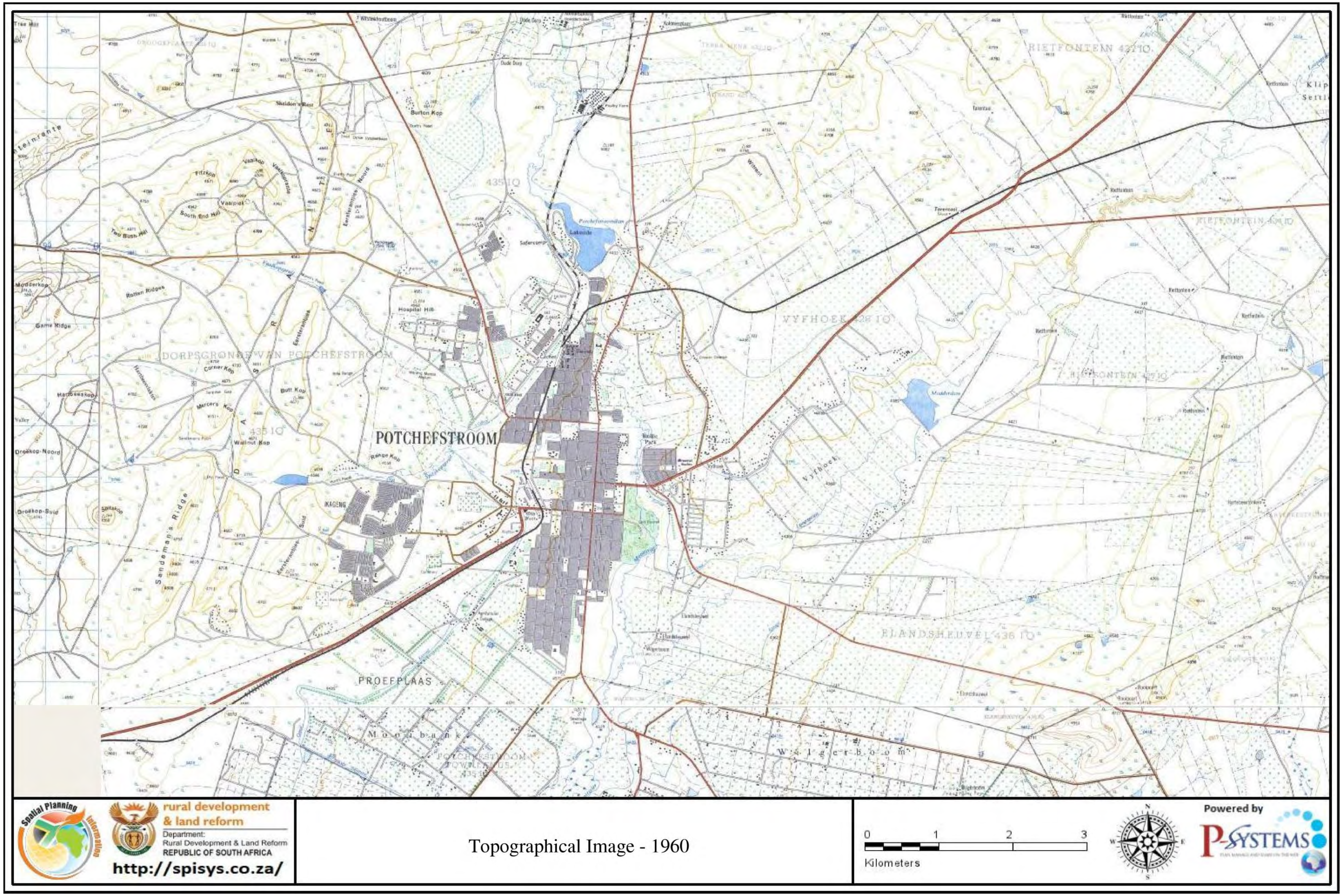

Figure 4.4: Topographical change – 1960

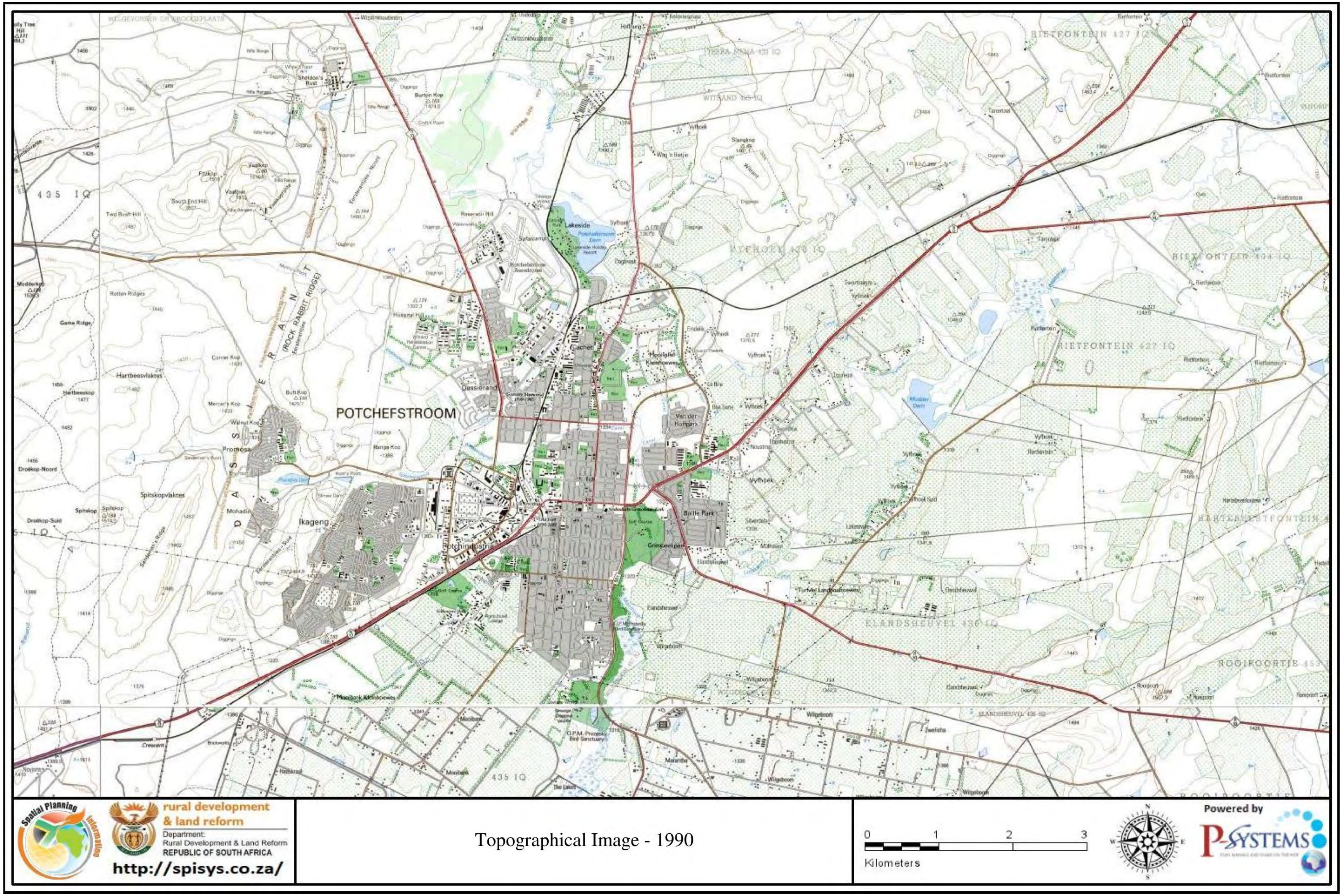

Figure 4.5: Topographical change – 1990

4.3.2 Water supply infrastructure

DWA (2011) identified the water supply infrastructure and the information was summarised in Table 4.3.

Table 4.3: Potchefstroom water supply infrastructure

ID	Approx. Capacity	Location	Water Use
Klerkskraal Dam	8.25 million m^3	On Mooi River upstream of Boskop Dam	Irrigation
Boskop Dam	20.85 million m^3	On Mooi River upstream of Potch Dam	Supply irrigation and urban water requirements
Gerhard Minnebron Canal	Spring	Upstream of Boskop Dam	Water supply to Boskop Dam
Potchefstroom Dam	2.03 million m^3	Downstream of Boskop Dam	Irrigation and domestic use

According to the Water Services Development Plan (WSDP) compiled by the Tlokwe Local Municipality for February 2012, the number of sources and water abstractions for the different water resources is as follows:

- The number of groundwater abstraction sources (2) predominantly used for rural water supply; abstraction per day: 1 Mℓ/day; and
- The number of surface water abstraction sources (1) used for predominantly urban water supply; abstraction per day: 38.36 Mℓ/day, which is more than the licensed abstraction (20 Mℓ/day).

4.3.3 Water losses

The Water Services Development Plan (WSDP) shows the water losses, as well as a water balance from input and output measurements (Table 4.4) and how much is used and discharged (Table 4.5). The water balance amounts to a 60% (21 Mℓ/day) loss, which includes discharged wastewater with used or contaminated load. The units in the tables are all in Mℓ/day.

Table 4.4: Water losses (Tlokwe, 2012:22A)

Water losses	Raw water @ treatment	Total raw water (bulk received)	Raw water supply	=	% Loss
Raw water bulk losses	38.36	38.36	0	0	0
Treated water loss: bulk	37.5	37.5	-	0	0
Treated water loss: internal	34.5	37.5	-	-3	-9

Table 4.5: Water balance (Tlokwe, 2012:22A)

Water balance	Input	Usage + Discharged	Value	% Loss
	37.5	57	22.5	60

4.4 Geological setting

4.4.1 Historic structural and regional geology

The Vredefort Dome is a dominant feature within the area of Parys as well as the greater Parys area, which extends towards Potchefstroom. Due to the close proximity of the Vredefort Dome to Potchefstroom and taking into account the immense impact the event had on the geology, a review of the geological conditions prior to the event as well as the geological conditions post the impact event were assessed.

The geology underlying the Vredefort structure varies from sequences through the Pre-Cambrian to early Archaean (3.3 Ga of age) to early Proterozoic (2.4 Ga). Figure 4.7 shows the geology of the Vredefort Dome on a regional scale.

Detailed structural analysis and mapping of geotraverses across the Vredefort Dome have enabled the differentiation of the following various structural events (Colliston *et al*., 1996:1; Brink *et al*., 2000:100) as discussed in the following sections.

<u>Pre-Vredefort events</u>

The area was underlain by structurally complex early Archaean basement (Witwatersrand Basin) with sub-horizontal tectonics, followed by an extensional tectonic phase (formation of ductile NW & NE striking shear zones). Regional scale metamorphism was evident due to the large portions of migmatite outcrops on the surface.

From ±3.06 to 2.4 Ga, a period of deformation, followed by trust faulting and regional thermal events dominated the area at approximately 2.4 to 2.52 Ga. Thereafter followed the emplacement of the major intrusive phases of the Bushveld Igneous Complex (approximately 2.023 Ga).

<u>During and post-Vredefort impact</u>

On a megascopic scale a circumferential synclinal and anticlinal fold pattern was evident as the basement and collar strata overturned, facing the point of impact and thrust fault zones formed. Heavy faulting and folding of pre-Vredefort structures on a mesoscopic scale lead to the development of mid-amphibolitic grade metamorphism with fabric imprints reflecting a high strain event such as shock deformation (pseudotachylitic breccias, shatter cones, curved and brittle cleavage).

Beyond the collar lies the Potchefstroom synclinorium, which gradually deepens towards the north. This synclinorium is characterised by strongly folded strata.

To the south of the dome, the sequences of the Witwatersrand Supergroup lie sub-horizontally, with a shallow dip toward the south.

Figure 4.7 shows the current underlying geology of the Vredefort Dome, illustrating the disposition of the different lithologies and terranes, as taken from Kamo *et al*. (1996:371). Figure 4.8 presents the fold patterns associated with the Potchefstroom synclinorium which concentrically surrounds the Vredefort Dome as well as the faulting delineations after the impact event in the underlying geological sequences, which also adopted a concentric formation around the dome to the north (after McCarthy cited by Reimhold & Gibson, 1996:132). Figure 4.6 presents a regional geological map.

Groundwater flow usually favours the path of least resistance. It will therefore occur mostly in weathered zones, fractures, faults, joints or any structural weaknesses within the geological sequences.

The heavy faulting from the regional impact event may have had a direct impact on the aquifer connectivity linking the various aquifer systems present in the area.

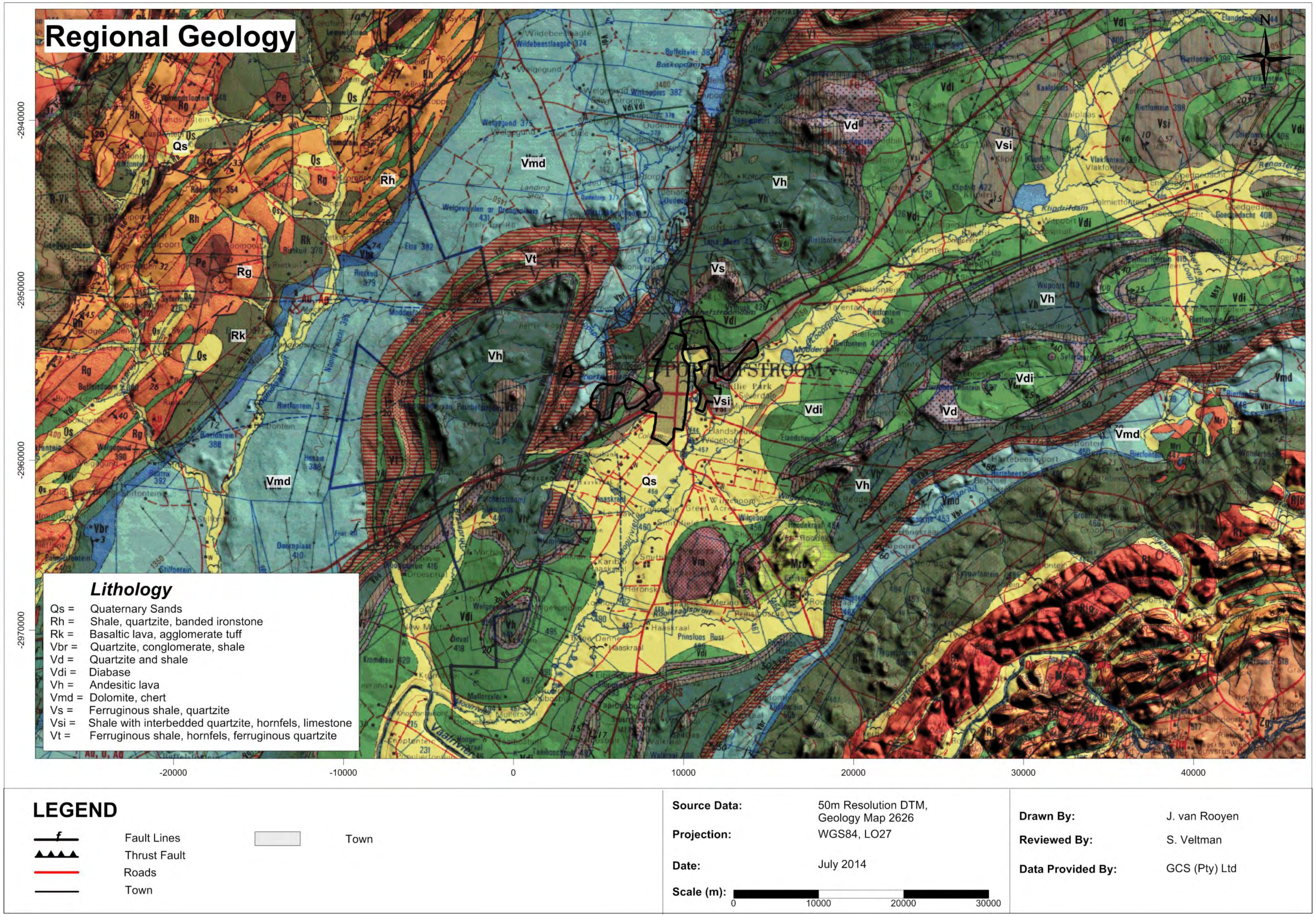

Figure 4.6: Regional geological map

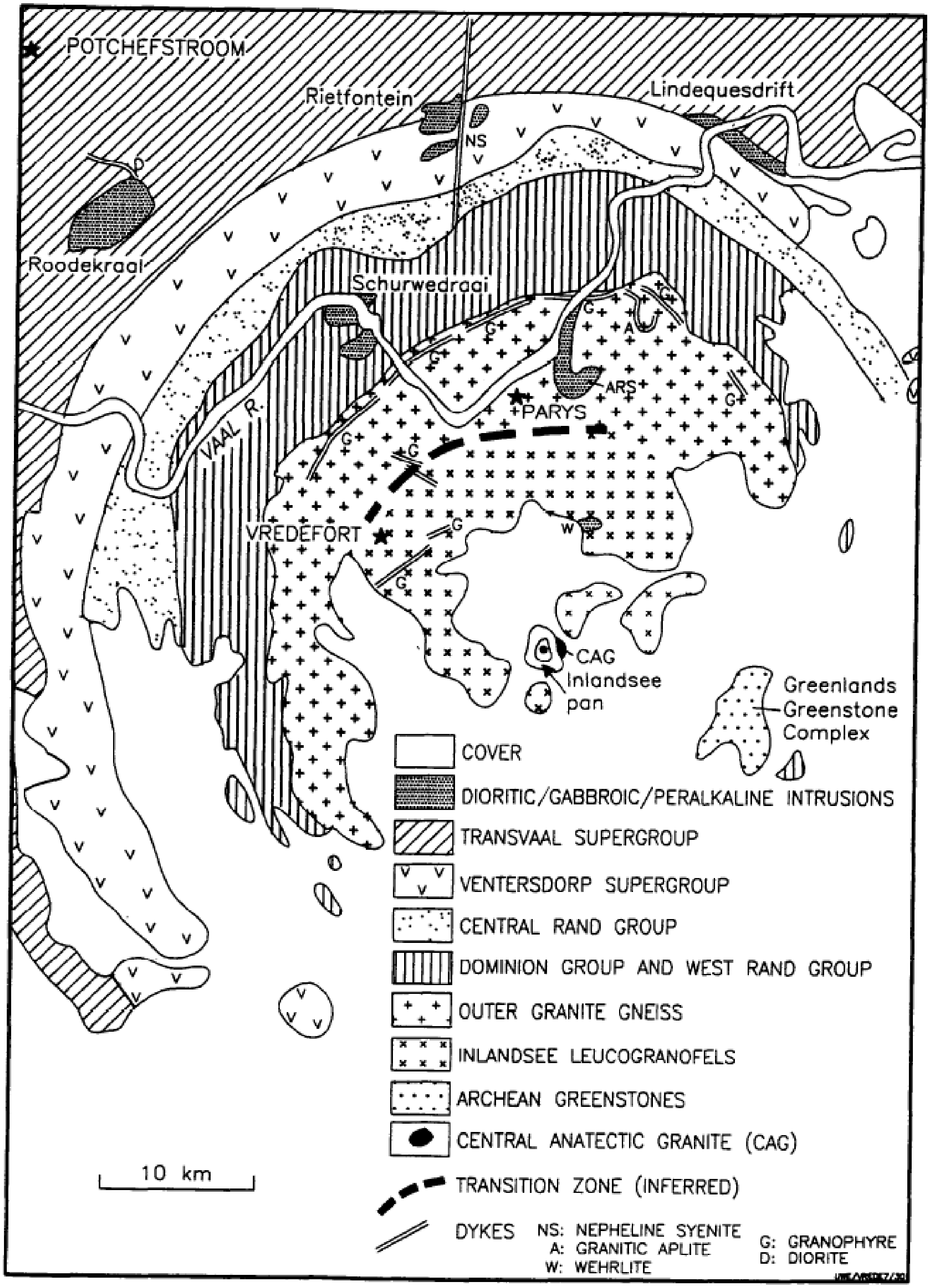

Figure 4.7: Geology of the Vredefort Dome structure (Kamo *et al*., 1996:371)

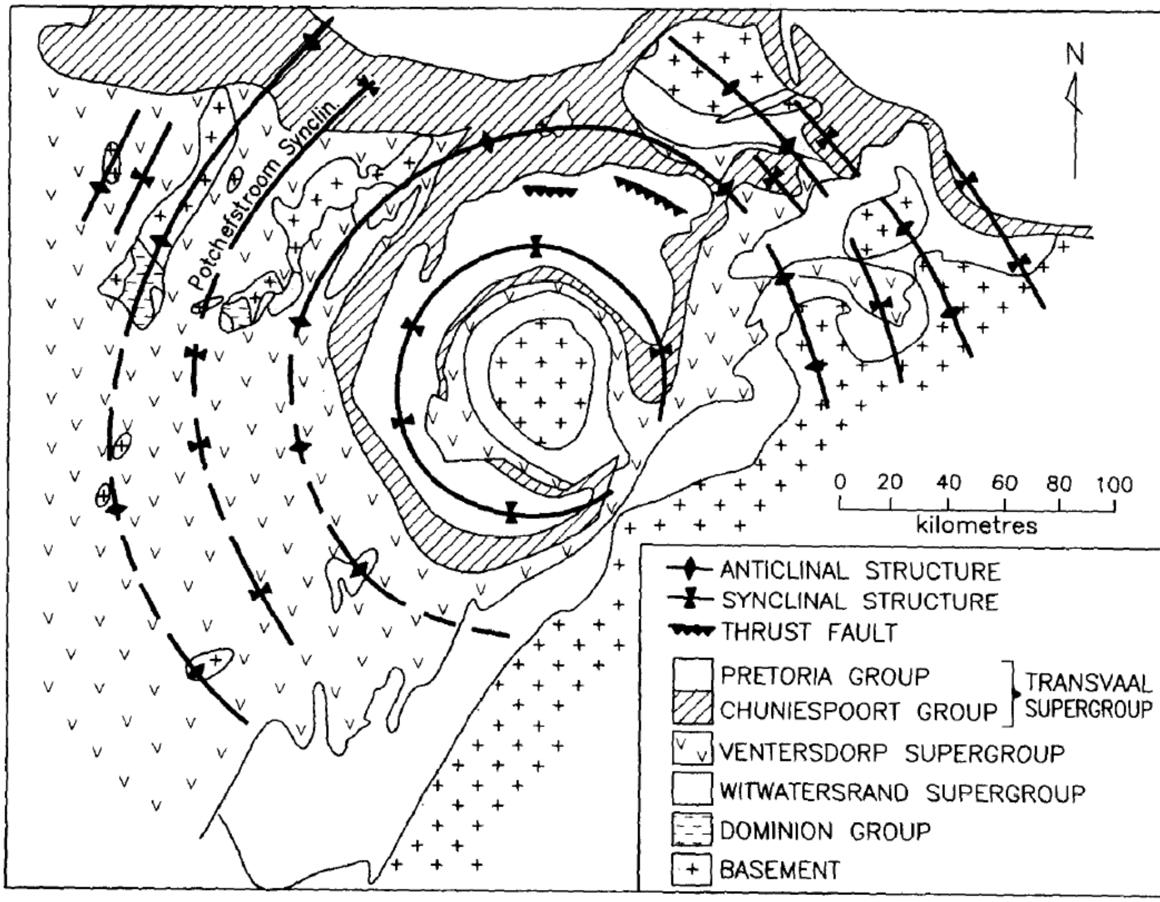

Figure 4.8: Fold and fault patterns after Vredefort Impact Event (after McCarthy cited by Reimhold & Gibson, 1996:132)

4.4.2 Local geology

Strata belonging to the Witwatersrand Supergroup, Ventersdorp Supergroup and the Transvaal Supergroup are found within the greater Vredefort Dome area. The geology underlying Potchefstroom is quite complex due to the high impact of the Vredefort event that caused heavy faulting and anticlinal (recumbent folding) formations. Potchefstroom is predominantly underlain by lithologies from the Transvaal Supergroup.

An evaluation of the map sheet West Rand 2626, 1:250 000 (Council for Geoscience, 1978) revealed the following geological information:

- The western part of Potchefstroom:
    - Is underlain by lithologies from the Pretoria – as well as the Chuniespoort Groups, which forms part of the Transvaal Supergroup and consists of dolomite, chert, ferrugineous shale, hornfels and quartzite.

- The presence of intrusive diabase rocks from the Vaalian Era (2 650–2 500 Ma) as well as a large thrust fault system (strike: north, dip: 10°) to the SW of Potchefstroom with an adjoining normal fault system to the NE.
- The central part of Potchefstroom:
    - The Pretoria Group lithologies are mostly dominant, consisting of andesite, agglomerate, tuff, ferruginous shale, ferruginous quartzite and shale with interbedded quartzite, hornfels and limestone. There is evidence of a large diabase intrusion covering most of the NE and SW part of Potchefstroom.
    - The north central part of Potchefstroom is underlain by the Black Reef Formation from the Chuniespoort Group. There is thrust fault system to the NE with an adjoining normal fault system continuing north.
- The eastern part of Potchefstroom is underlain by quaternary sediments and alternating layers of the Pretoria Group and diabase intrusions.

Hydrogeologically, the presence of the various fault systems described above may form preferential flow paths for groundwater flow as well as possible contaminant transport.

4.5 Hydrogeological setting

It was evident from the geological discussion that three aquifer types are present in the Potchefstroom area. The characteristics of each aquifer vary and are generally interconnected by fractures and faults:

- Alluvial aquifers in areas surrounding the rivers and a shallow aquifer formed in the weathered zone, perched on the fresh bedrock;
- A deeper aquifer formed through secondary fracturing of the parent rock and intrusive formations (i.e. igneous and dolerite intrusions); and
- A dolomite and limestone-rich aquifer (karst in places) of the Malmani Subgroup.

4.5.1 Alluvial and shallow weathered aquifer

Unconsolidated colluvium and weathered sediments overlie the consolidated formations and dolerite intrusions. The underlying mudstones, clays and siltstones result in perched aquifer conditions. The depth of the weathering range between 5 to 12 metres below ground level (mbgl) in the study area and experiences relatively high recharge from rainfall (4.7%). This aquifer is low yielding (1 200 to 12 000 ℓ/day) due to the limited thickness.

Surface water infiltration and recharge from rainfall usually also interact with this particular groundwater aquifer; therefore, this aquifer is important for risk quantification, as it often acts as a pathway for contaminants migrating from surface activities to surface water bodies, such as rivers.

Barnard (2000:1) classify the alluvial aquifer as intergranular due to the distinguishing hydraulic connections of permeability.

4.5.2 Fractured rock aquifers

Most of the groundwater flow will be along the fractures, cracks and joints that occur in the rock. These conductive zones effectively interconnect the underlying strata, both vertically and horizontally into a highly heterogeneous and anisotropic unit.

The dolerite (sill and dyke) and granitic intrusions prevalent in this area generally act as aquitards and compartmentalise the groundwater regime. However, metamorphosed, cracked and fractured contact zones between the host rock and the intrusions often represent highly conductive groundwater flow paths. The horizontal and vertical extensive nature of the dolerite intrusions means that these conductive zones are interconnected and govern groundwater flows. The aquifer characteristics of these contact zones are heterogeneous.

According to Barnard (2000:1), the variable geology in the study area presents characteristics of the intergranular and fractured regime, which indicate groundwater storage and flow occurs mainly within the fractures of the rock. Dominant yield classes vary from 0.1–0.5 ℓ/s to 2.0–5.0 ℓ/s.

4.5.3 Dolomitic aquifer

The Chuniespoort Group dolomites, which form part of the Transvaal Supergroup, mainly consist of alternating layers of chert-poor dolomite and chert-rich dolomites. According to Barnard (2000:1), the recharge values can be as high as 13.9% of the mean annual precipitation in this aquifer.

The Malmani Subgroup forms the major aquifer system, which is normally high yielding and produces good quality water. This aquifer can be classified as a karstic aquifer (Barnard, 2000:2), denoting cavities associated with fracturing and jointing and the groundwater yield is normally more than 5 ℓ/s. An effective depth of 300 m has been accepted as the maximum depth to which significant dissolution of the dolomite has been taking place. A hydraulic conductivity that varies between 10 to 100 m/day is considered representative of the Malmani dolomite.

4.6 Regional groundwater levels

4.6.1 Non-time series boreholes

The non-time series boreholes from the NGDB were only measured once and each of the measurements ranges between 1950 and 1993. A total of 276 NGDB boreholes were selected in a 20 km radius around the town. A summary of the NGDB boreholes used for the analysis is provided in Appendix A.

The static water levels for the NGDB boreholes measured in the site area ranged between 0.01 to 85.3 meters below ground level (mbgl) with an average groundwater level of 18.5 mbgl for the area.

The average groundwater elevation for the study area was calculated to be 1 377 meters above mean sea level (mamsl)[1] and ranged between 1 258 mamsl to 1 522 mamsl. Figure 4.9 shows the linear correlations between topography and groundwater level acquired from the NGA boreholes in the study area.

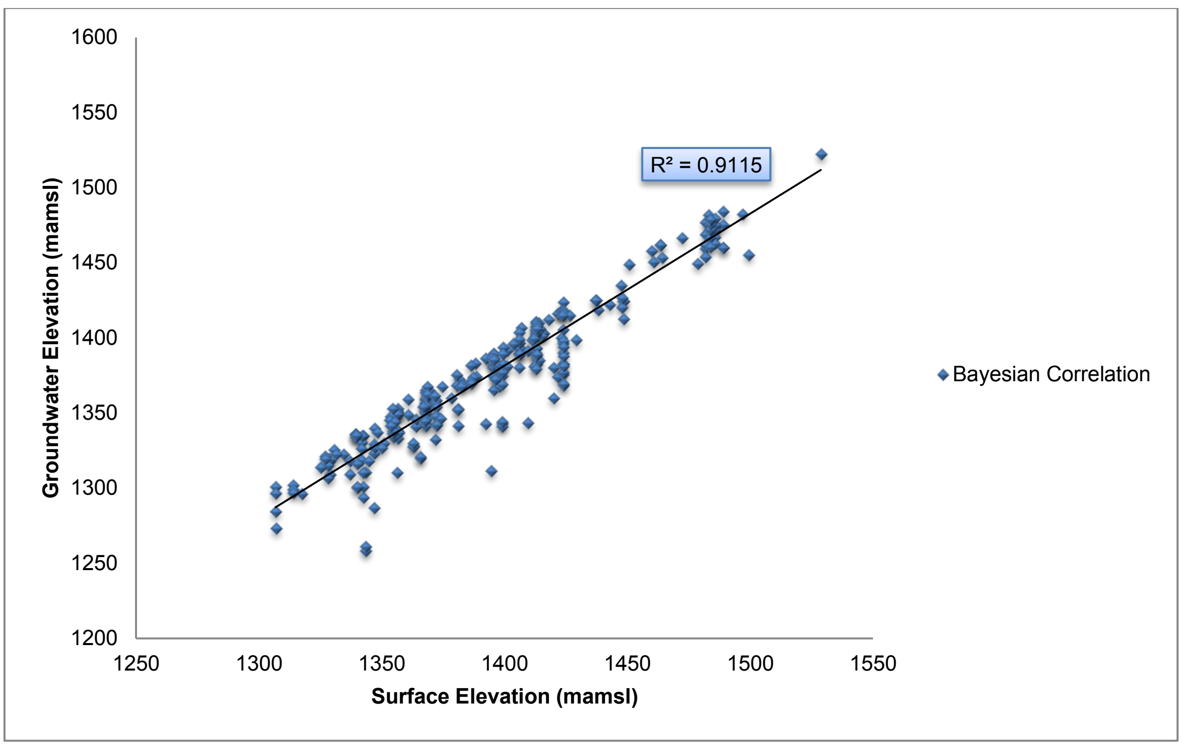

Figure 4.9: Regional Bayesian correlation

[1] Elevation data obtained from 50 m resolution DTM.

Figure 4.10 and Figure 4.11 show the linear correlation between the groundwater levels and topography further compared to the local geology of each borehole group. Only the main lithologies for each of the borehole groups were taken and included in the correlation. The linear correlations of the water levels versus the geology showed that there was a good correlation with the following geologies:

- Dolomite and Chert (89%) – karstic aquifer characteristics;
- Dolomite and Andesitic lava (87%) – possible metamorphosed, cracked and fractured contact zone;
- Diabase and Andesitic lava (95%) – intergranular and fractured characteristics; and
- Alluvium and Diabase (94%) – shallow weathered and fractured contact zone.

The following geologies displayed a fair linear correlation of 61%:

- Tholeiitic basalt – minor jointing and fracturing within the parent rock with aquaclude characteristics.

The Dolomite and Diabase geology showed a poor linear correlation (39%). Outlier boreholes 2626DD00019 and 2626DD00021 are located near a chicken farm and these boreholes may be linked to high abstraction for water supply purposes.

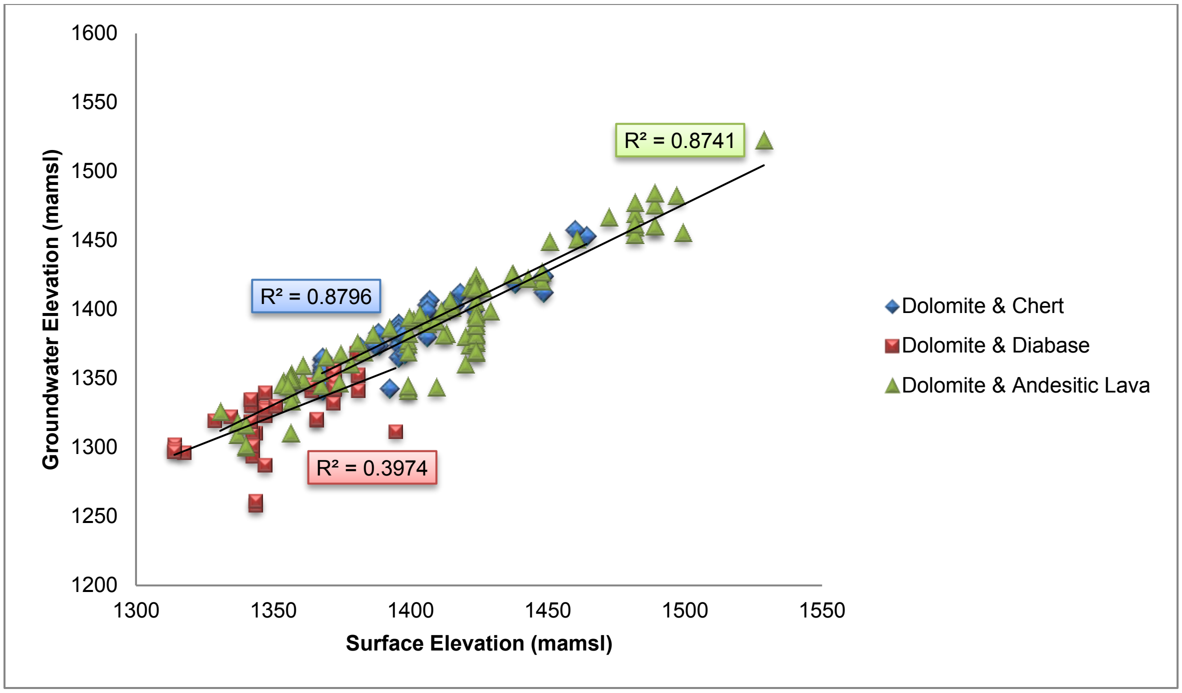

Figure 4.10: Water levels versus geology (Part 1)

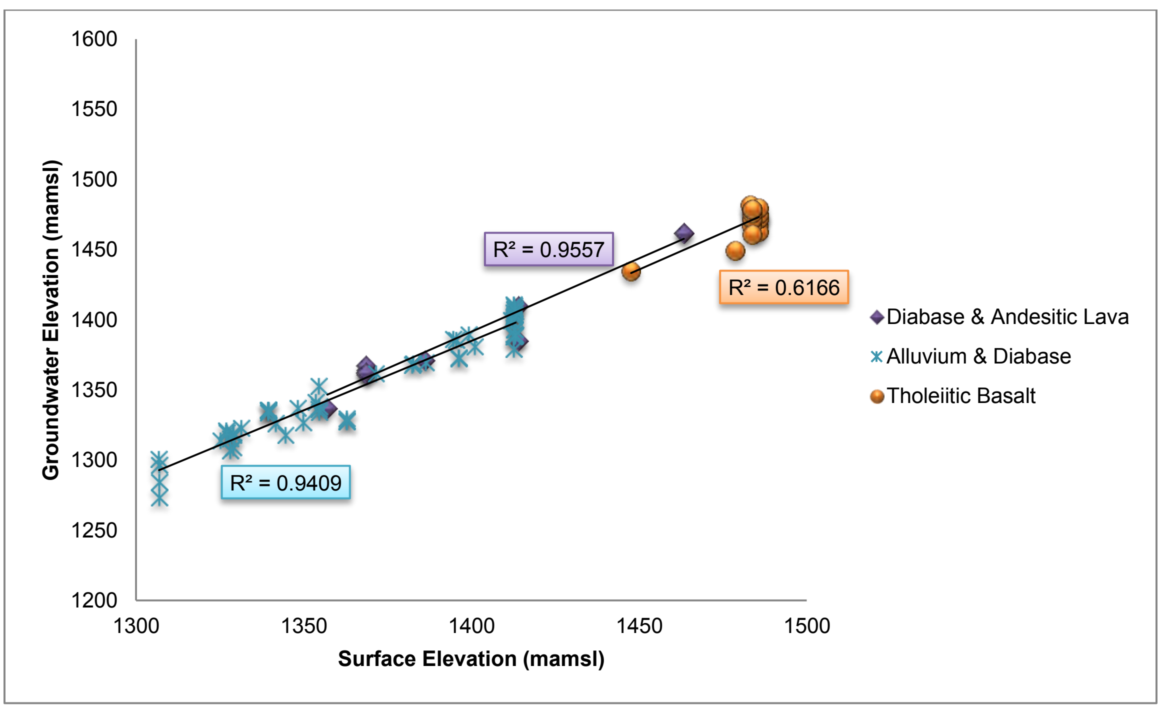

Figure 4.11: Water levels versus geology (Part 2)

4.6.2 Time series boreholes

In the same 20 km radius area around the town, only five (5) boreholes had time series data. The collective period for monitoring ranged from 1959 to 2005. The static water levels for the time series boreholes ranged between 5.8 and 96.7 mbgl with an average groundwater level of 51.3 mbgl.

Figure 4.12 presents the time series groundwater levels over time. Each of the time series boreholes was again compared to the underlying geology and was also incorporated into the figure.

The andesitic lava (generally associated with low storage capacity) underlying borehole 2627CA00194 is interpreted as a more competent unit, also due to the relatively consistent groundwater levels over time and the lava underlying borehole 2626DD00261 is more porous, with fractures and joints, which explains the varied groundwater levels. The groundwater levels compared to rainfall events did not show any response to rainfall events; however, one instance in 1977 showed that there was a singular lag time recharge from rainfall.

Table 4.6 below presents the time series boreholes used for the analysis. Figure 4.13 shows the borehole positions of the non-time series boreholes as well as the time series boreholes.

Table 4.6: Time series borehole summary

BH ID	Coordinates (WGS84, LO27)		Elevation
	X	Y	(50 m DTM)
2626DD00251	-14483.76	-2973448.14	1335
2626DD00119	-12905.58	-2964918.06	1366
2626DD00261	-283.40	-2964203.46	1372
2627CA00193	5596.52	-2959595.42	1349
2627CA00194	13585.80	-2933148.45	1409
2627CA00001	11758.19	-2932526.18	1399

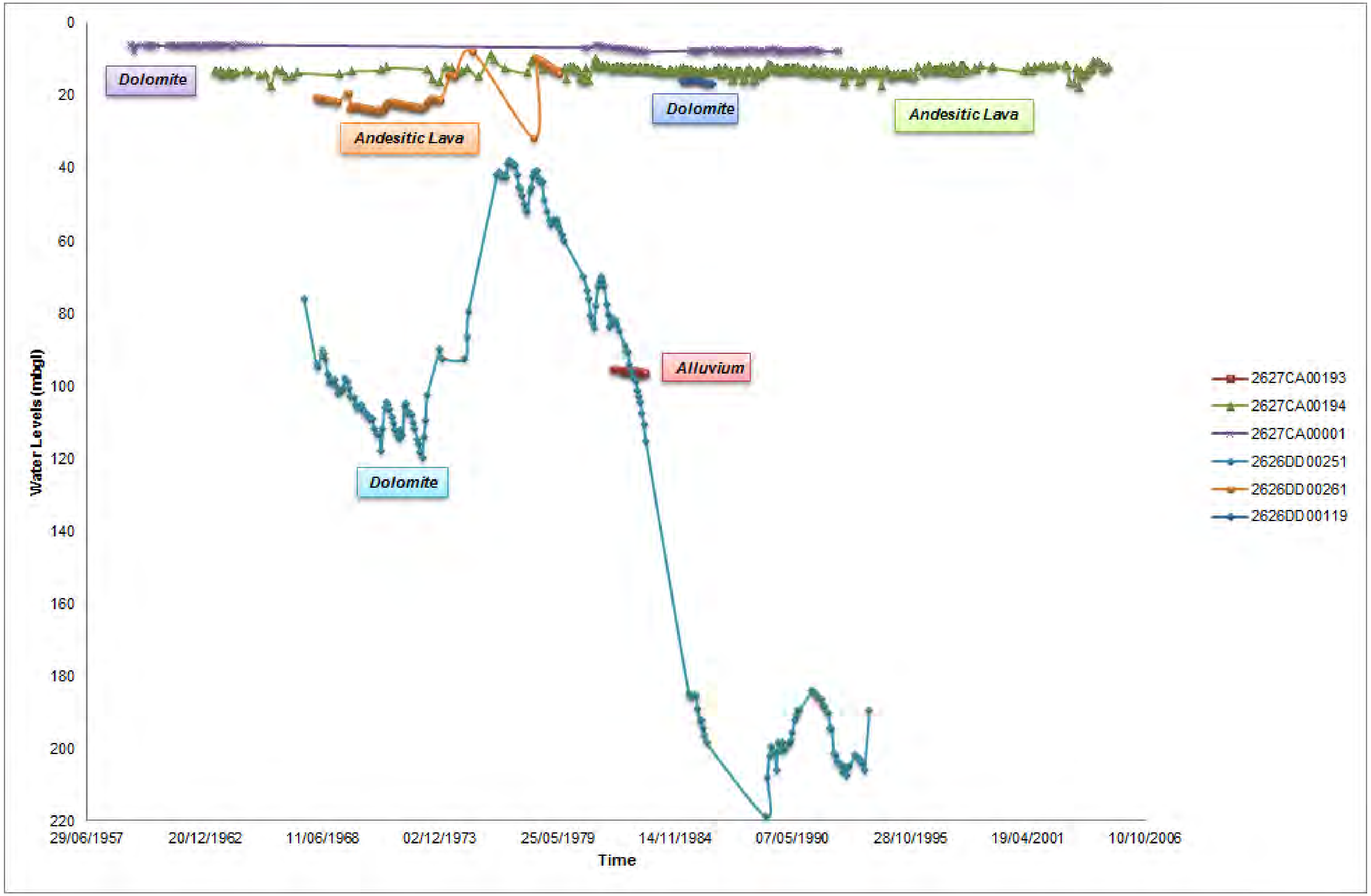

Figure 4.12: Time-series groundwater levels vs. geology

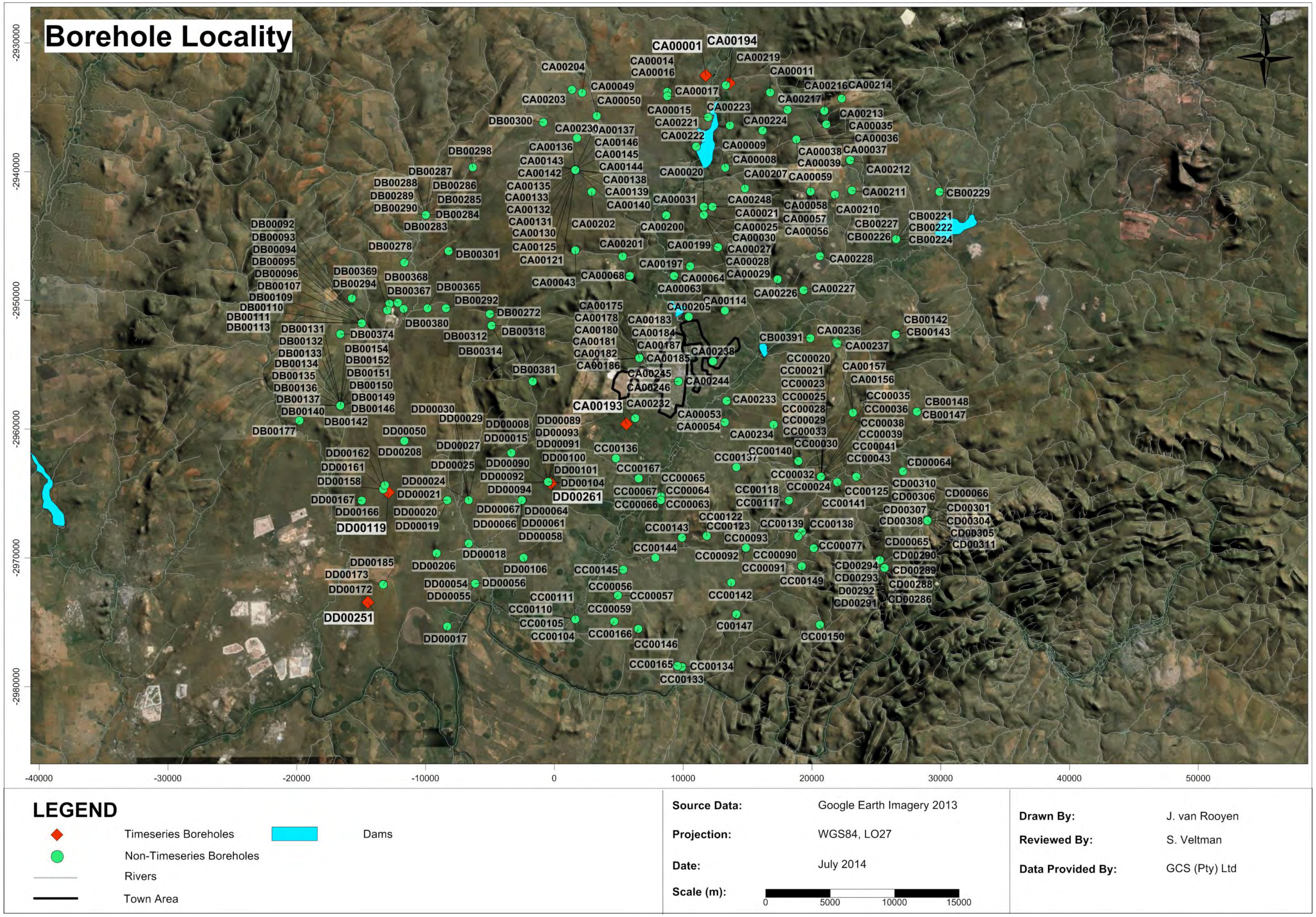

Figure 4.13: Borehole locality map

4.7 Hydrochemistry

4.7.1 Groundwater quality

Groundwater quality data were collected for four (4) DWA boreholes in the 20 km radius around the town were monitored. Documentation, coupled to the data download stated that the samples were taken 20 cm below the static water level and were not preserved before the samples were sent the laboratory. The period during which the boreholes were monitored was from June 1995 to May 2003 collectively. The groundwater hydrochemistry results are presented in Appendix B.

The baseline groundwater characteristics were presented in the form of Piper[2] and Durov diagrams for the analytical results collected.

The dolomitic aquifer within the study area is considered a major aquifer, which has naturally higher calcium, magnesium and bicarbonate concentrations, commonly associated with recently recharges and fresh groundwater. ZQMPFM1 was drilled to a depth of 50 mbgl. It is situated in a dolomitic aquifer from which water is regularly pumped. The other sampled boreholes are underlain by mudstone, quartzite and tholeiitic basalts. No additional boreholes located within the dolomites are present with any open-source chemistry data for analysis for comparison to ZQMPFM1.

The analytic results for all of the boreholes were averaged and presented in the Piper and Durov diagrams below (Figure 4.14). The Piper (a) and Durov diagrams (b) were used to classify the groundwater characteristics. The overall dominant water type for all of the sampled boreholes presented in Figure 4.14 (a) shows calcium/magnesium/bicarbonate-rich water, which is indicative of an aquifer that has recently been recharged. This is also an indication of unpolluted water. The Durov diagram, Figure 4.14 (b) shows that the groundwater has possibly been in contact with a sodium (Na)-rich source or old stagnant water that resides in an Na-rich host rock/material.

Figure 4.15 shows the localities of the sampled surface water as well as the sampled boreholes.

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[2] The Piper diagram is a tri-linear plot that groups the water chemistry of the samples according to their environment. It plots the major ions as percentages of milli-equivalents in two base triangles. The total cations and the total anions are set equal to 100% and the data points in the two triangles are projected onto an adjacent grid. This can show similarities in groundwater composition as well as the dominant groundwater type.

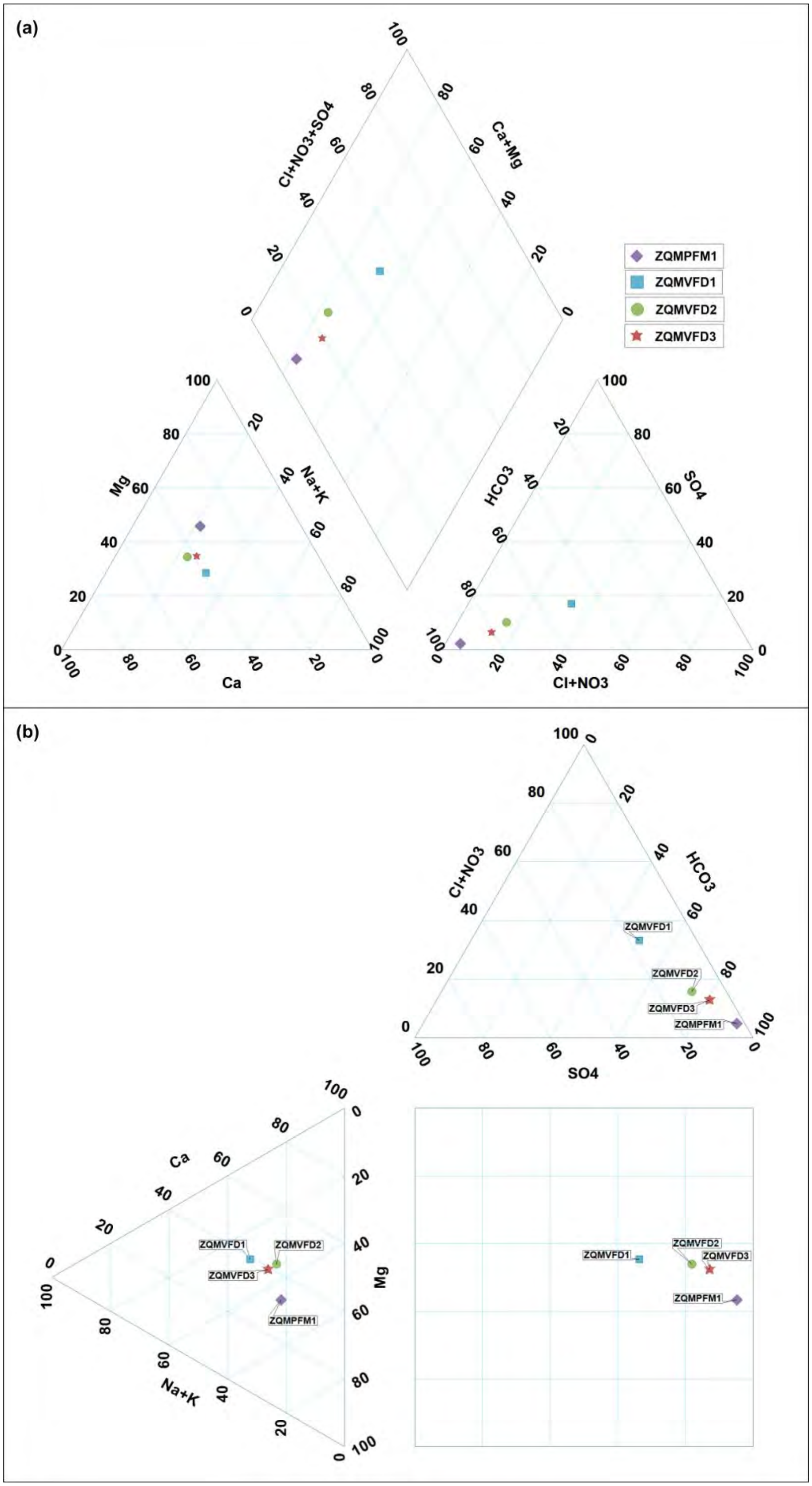


Figure 4.14: Piper (a) and Durov diagrams (b) for all sampled boreholes

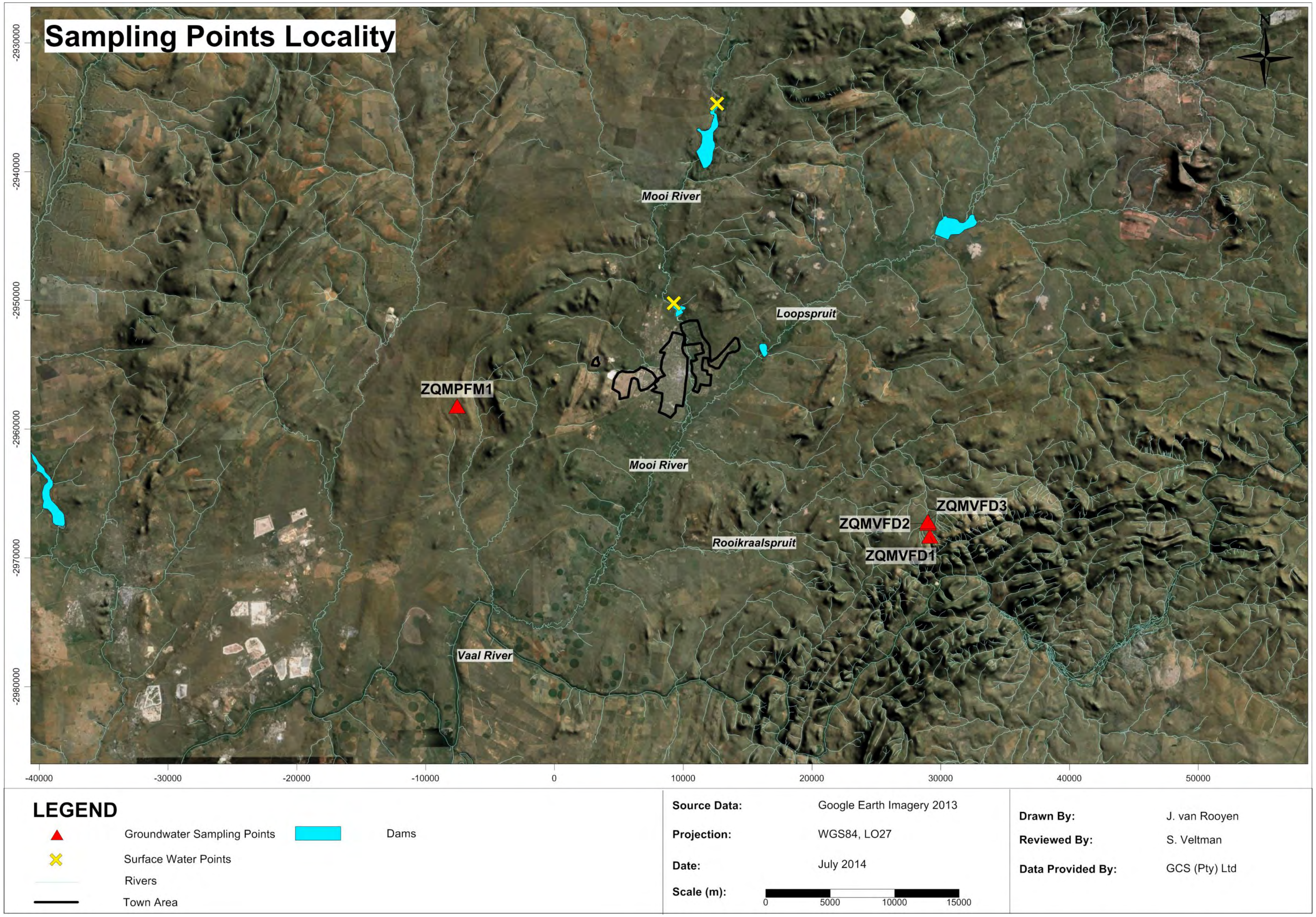


Figure 4.15: Surface and groundwater sampling points

4.8 Conceptual modelling

4.8.1 Conceptual development

Constraints in this particular area were the lack of available data concentrated in the urban area to comprehensively analyse and understand the aquifer system. Many assumptions were based on already analysed data, understanding of the behaviour of the defined aquifers, urbanisation principles (impermeable surfaces, leakage of pipelines leading to increased recharge and the mounding effects of the water table) and underground systems from literature.

Fetter (2000:84) report that the hydraulic conductivity in unconsolidated or unconfined aquifers is normally high. It is also the aquifer most vulnerable to the transportation of dissolved contaminants, with little attenuation other than dilution. These aquifers are close to a recharge source, such as streams, rivers or lakes/dams, as in the case of the Mooi River flowing through Potchefstroom.

The porosity of intrusive igneous and highly metamorphosed crystalline rocks is generally very little and groundwater flow is governed by fracturing, faulting or weathering. Hydraulic conductivity is typically quite high, except for intrusive dykes and sills.

Fresh dolomite is almost impermeable, with very little primary porosity. Due to structural processes, a network of faults, fractures, joints, weathered zones and solution cavities has formed in the dolomites, which is revered as hydrogeologically important aquifers. Dolerite dykes are mostly impermeable, but are less permeable than karstified dolomites, which divide the dolomites into a series of compartments (DWAF, 2006b:7).

Zones of deep weathering and tensional fractures within the dolomites are important controls as the displacements penetrate through the dolomite and forms conduits for groundwater flow, which potentially poses as a hazard for mine workings contamination. The high variation in transmissivity of dolomite results in a flat original water table with a low gradient from one compartment to the next. Solution cavities and fissures will become larger over time by rapid circulation of water infiltrated from surface; therefore, increasing the transmissivity and storage. Recharge increase from surface may lead to extensive development of subsidence areas and sinkholes (DWAF, 2006b:17).

The source-pathway receptor principle was applied to the development of the conceptual model and these are discussed below.

Figure 4.16 presents the conceptual cross section, coupled with the natural topographical environment. Re+ represents areas where recharge takes place and Re- indicates areas with no recharge.

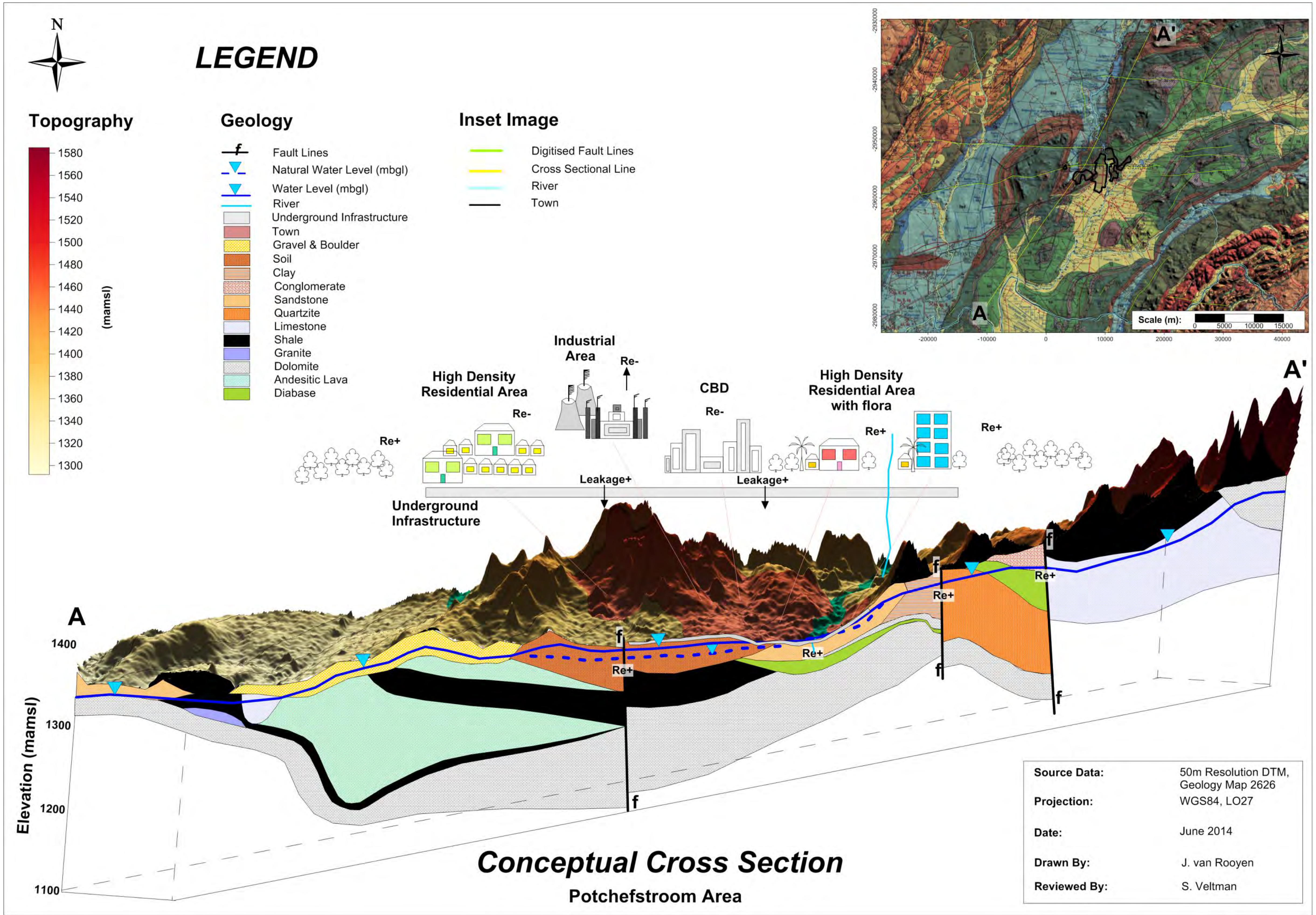


Figure 4.16: Conceptual cross section

CHAPTER 5

5 APPLICATIOIN OF RISK ASSESSMENT METHODOLOGIES

5.1 Preface

As part of the first principles of hydrogeology, a qualitative risk assessment evaluation was completed for the Potchefstroom case study. Different methods were tested and compared. This Chapter also include the shortfalls encountered during the numerical modelling.

5.2 Qualitative risk assessments

The following risk methodologies were performed and compared in order to effectively determine the appropriate tool to identify the risks of urbanisation:

- Environmental risk assessment;
- Fuzzy logic; and
- The DRASTIC method.

5.2.1 Environmental risk assessment

It is important to note that the impacts identified in this section were based on an existing urban area and very little information is available pre-urbanisation.

The impacts identified do not represent the overall impact, but only address the expected impacts associated with changes to the environment.

The environmental risk assessment was approached in identifying potential impacts and the different phases or activities of urbanisation in which the impact occurred.

The impacts were documented in the form of a table format. Table 5.1 and Table 5.2 provide the impacts identified with significance points with regard to the criteria discussed in Section 2.8.2.

A number of activities associated with urbanisation were identified and an impact rating was assigned to each activity in which high negative risks to the environment as well as positive environmental contributions were identified:

- Construction clearance;
- Construction of hard surfaces;
- Water supply infrastructure;
- Sewerage infrastructure;

- Filling stations;
- Effluent discharge;
- Contaminated urban runoff; and
- Monitoring.

Please note this is not the complete list of activities – however they are used to demonstrate the methodology.

It was noted that the activities that generated the highest risk ratings were construction clearance, effluent discharge and urban runoff.

It will be established in the next section with the use of the Urban Risk Assessment tool how the different contaminant sources may influence the quality of the water discharged from industrial activities.

Table 5.1: Environmental risk assessment results (adapted from GCS, 2014)

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
		M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
Anthropological – urban areas																
Changing the natural landscape due to soil stripping	Construction clearance	8	5	1	5	70	-	H	Possibly reduces the footprint area	6	5	1	3	36	-	M
Clearing of topsoil and altering topography for new urban developments can increase infiltration to groundwater and decrease soil buffering capacity	Construction clearance	6	2	1	3	27	-	L	Prevent ponding of water and commence construction as soon as possible	6	2	1	3	27	-	L
Surface cover leading to surface impermeability	Construction of hard surfaces	4	5	2	5	55	-	M	No mitigation possible, as this is a permanent change to the environment	4	5	2	5	55	-	M
Rainfall recharge to groundwater decrease due to paving and increase in amenity areas	Construction of hard surfaces	4	5	2	5	55	-	M	No mitigation possible, as this is a permanent change to the environment	4	5	2	5	55	-	M
Installation of water supply pipelines and construction of reservoirs for water storage	Water supply infrastructure	6	4	2	4	48	+	M	Regular maintenance will decrease leakages and increase functionality	6	4	3	5	65	+	H
Leakage of underground pipelines into groundwater systems	Sewerage infrastructure	4	2	2	3	24	-	L	Regular maintenance and upgrades of deteriorated material will decrease leakages and increase functionality	4	3	2	4	36	-	M
Leakage of fuel tanks into groundwater systems	Filling station leakage	8	4	1	4	52	-	M	Inspection of equipment/tanks, proper management of installation and implementation of a maintenance plan in order to decrease impact on the environment	3	2	3	4	32	-	M
Increase in groundwater contamination due to industrial activities such as food and beverage factories, tanneries, abattoirs, breweries and fertiliser production factories to either infiltrate into groundwater or to runoff to surface water bodies	Effluent discharge	8	4	2	5	70	-	H	Management of activities and implement environmental awareness and responsibility	6	4	2	4	48	-	M

Table 5.2: Environmental risk assessment results (continued)

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
		M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
Anthropological – urban areas																
Increased runoff of polluted water from the impermeable urban surfaces to the immediate clean surrounding environment	Contaminated urban runoff	8	5	2	5	75	-	H	Identify contamination sources, address and mitigate to decrease chances of contamination to outside environment	6	4	3	4	52	-	M
Water quality deterioration in the vulnerable aquifers and in the river valleys and lower topographical areas	Contaminated urban runoff	8	5	3	4	64	-	H	Identify contamination sources, address and mitigate to decrease chances of contamination to outside environment	6	4	3	4	52	-	M
Baseline information is required for monitoring of water quality and quantity	Monitoring	6	4	2	4	48	+	M	Groundwater and surface water monitoring networks should be set up so that any quality or quantity issues can be addressed	8	4	2	5	70	+	H

5.2.2 *Fuzzy logic – Urban Risk Assessment (URA) tool*

As discussed in Section 2.8.3, with use of the URA tool, urban contaminant sources can be identified and the expected contaminants are given with a quantifiable risk percentage.

The tiered approach was used, the contaminant sources within the industrial area of Potchefstroom were identified, and each of the industrial activities was evaluated in the URA tool. The contaminant sources consisted of the following:

- Abattoir;
- Food and beverage manufacturing (Brewery, Nestlé and Tiger Brands);
- Cemetery;
- Cooperative (general agriculture and petrol station);
- Fertiliser manufacturing;
- Railway station/yard; and
- Tannery

Please note this is not the complete list of activities – however they are used to demonstrate the methodology.

Tier 0 describes only a general risk associated with the chosen contaminant source, with no reference of a specific site. This tier has a low confidence rating; however, when a quick risk is to be calculated, this will help the researcher a great deal.

Tier 1 incorporates recharge, soil types, aquifer media, geology, groundwater depth and topography in which site-specified information can be added to clearly define the risks of a specific site.

Tier 2 further calculates the aquifer vulnerability with specialised site information in the required fields.

In this study, only Tier 0 and Tier 1 were selected in order to give an indication of the urban risks for Potchefstroom, as more specialised information required for Tier 2 was not available.

Table 5.3 provides the identified contaminant sources as well as the accompanying information, which computes to the total risk percentages. The results from Tier 1 are selected to represent the calculated risk percentages for the industrial activities in Potchefstroom, as Tier 1 provides a site-specific risk rating.

It should be noted that it was assumed in the Tier 0 of the URA that the number of sources were low (typically 1–5) and the level of management was low (unsatisfactory). During the Tier 1 assessment, it was assumed that the exposure duration of contamination from the selected contamination source was more than 90 days but less than two years.

Table 5.3: Urban risk assessment results

Prioritisation	Source type	Source description	Expected contaminant	Tier 0: RA Total calculated risk %	Tier 1: RA Total calculated risk %
From High Priority to Low Priority Risk	Fertiliser manufacturing		Aldicarb	56	59
	Cemetery		Ammonium	58	56
	Cooperative	Petrol service station	Benzene	63	56
	Railway station		Benzene	62	56
	Abattoir		None	15	56
	Cooperative	Agriculture (General)	Arsenic	62	56
	Tannery		Arsenic	60	56
	Food and beverage	Brewery	Chlorine	60	56
		Nestlé			
		Tiger Brands			

As seen in the table above, the calculated overall risk percentage for the industrial activities listed is 56%. The highest risk is the fertiliser manufacturing company, which has a 59% risk for contamination to the environment.

It is important to note that should hydrochemistry information be available for these specified activities, the total calculated risks in the URA tool can be increased should an identified contaminant be added (which is also part of expected contaminants list). Should more information become available, the more accurate the calculated risk percentage will become.

5.2.3 DRASTIC

In order to determine the vulnerability of Potchefstroom's aquifers, the DRASTIC approach followed the principles as described in Section 2.8.4. The DRASTI method takes into account the geological and hydrogeological factors associated with the site. The site information is inserted into the required fields and the DVI values are calculated based on the data input. The DVI values were fractioned in order to establish a ranking system. It is important to note that the recharge values were based on the 603.5 mm/a MAP as discussed in Section 4.2. The recharge values were calculated in relation to the MAP of the area and were based on the different lithologies from which the information was collected from previously documented works (DWAF, 2006a:22).

Table 5.4 provides the results of the information inserted into the DRASTIC database together with the calculated DVI values and the established colour-coded ranking system. The chemistry results are presented in Appendix B.

Table 5.4: DRASTI Vulnerability Index (DVI) for the study area

Abbreviation	D	R	A	S	T	I	*DVI	Risk colour
Description	**Depth to water**	**Net recharge**	**Aquifer media**	**Soil media**	**Topography**	**Impact of Vadose zone**		
North of urban area	12.19	0.0001984	Karst formation	Poor	1	10	***144***	
	15.76	0.00005	Weathered metamorphic	Moderate	1	4	***127***	
	5.32	0.000007	Bedded sandstone	Moderate	1	6	***141***	
	11.51	0.0000499	Diabase	Poor	1	3	***137***	
Urban area	12.89	0.00005	Weathered Metamorphic	Moderate	4	4	***134***	
	27.06	0.000132	Sand & gravel	Good	4	8	***147***	
	11.13	0.000007	Bedded shale sequence	Moderate	4	6	***118***	
	6.56	0.0001984	Karst formation	Poor	4	10	***159***	
South of urban area	14.55	0.000132	Sand & gravel	Good	1	8	***162***	
Weight	**5**	**4**	**3**	**2**	**1**	**5**		

***DVI – DRATIC Vulnerability index**

LEGEND		
From	**To**	**Colour scale**
110	125	*Green*
125	140	*Blue*
140	155	*Orange*
155	170	*Red*

The area north of the urban areas is dominated by weathered metamorphic rocks, bedded sedimentary rocks and dolomitic formations, with intrusions of quartzites and diabase, which form part of two of the major aquifers (dolomitic and fractured) present in the area.

The fractured aquifer system showed relatively lower aquifer vulnerability in the DVI (blue and orange) colour ranking. The dolomitic aquifer showed a moderate (orange) vulnerability as groundwater is compartmentalised in this lithology.

Weathered metamorphic rocks and bedded shales on the eastern part of the urbanised area (residential area) pose a low vulnerability (green colour code). Further to the west in the industrial and CBD areas where andesitic lavas are present, a moderate vulnerability (blue) was designated. Dolomites are present in the western section of Potchefstroom and this is an area vulnerable to sink holes due to karstification of the dolomites. This aquifer has a high vulnerability (red).

In the south of the urban area where alluvials are present throughout, the aquifer vulnerability is high (red).

It can be interpreted that the aquifer vulnerability increases from north to south, which provides a good comparison to the flow of the river system as well as groundwater flow from north to south through the urban area. This statement is also supported by Figure 5.1, which provides a graphical representation of the calculated aquifer vulnerability using the DRASTI approach.

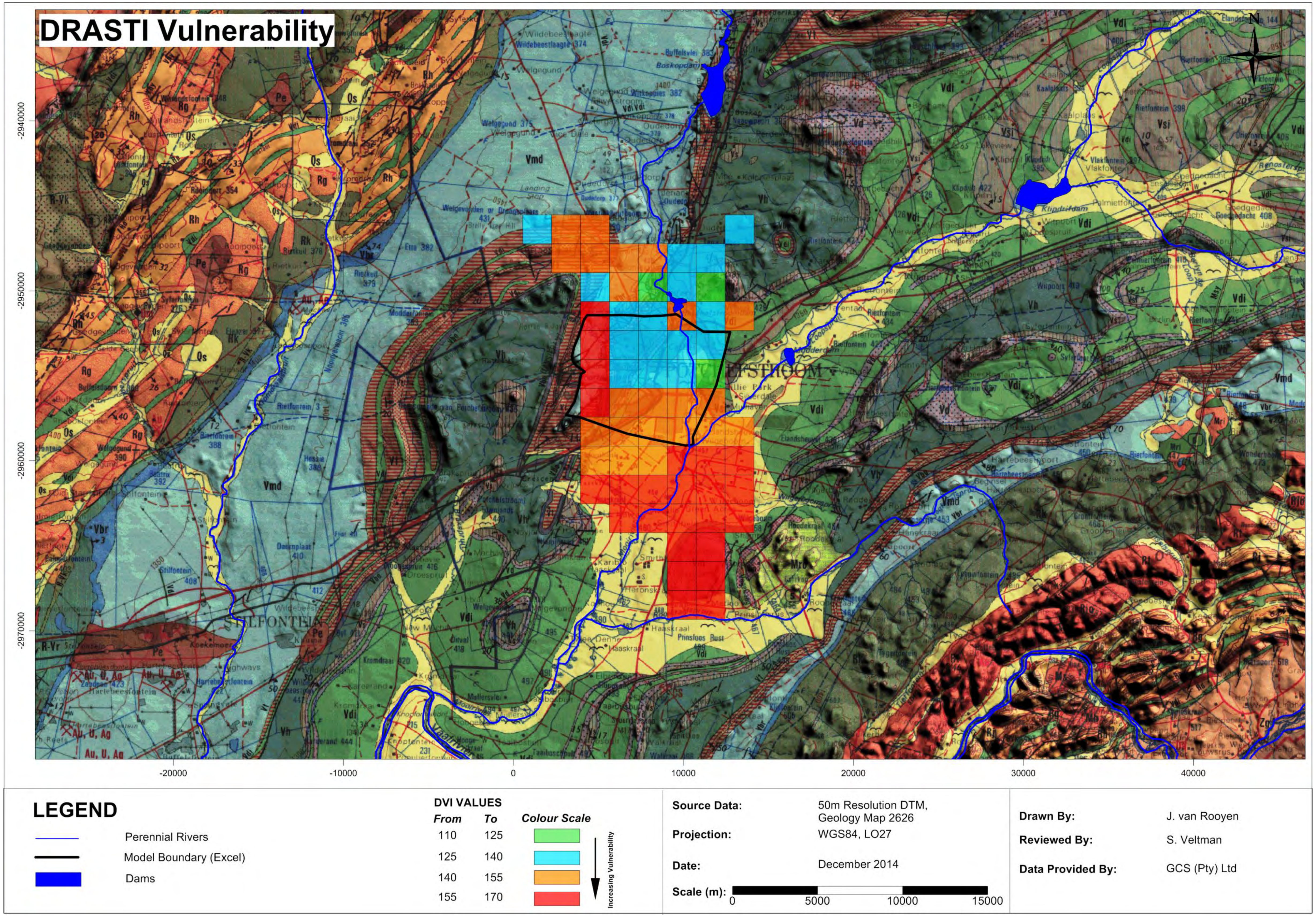


Figure 5.1: Aquifer vulnerability

5.2.4 Selection of the appropriate risk assessment tool

Each risk assessment tool is a qualitative method of identifying and determining the level of initial risks. The accuracy of the risk assessments is largely dependent on the user's understanding of the site. Urban problems are complex and necessitate large amounts of data and documentation; therefore, to select only one of the tools discussed in the above sections as the most appropriate tool to conduct a risk assessment is simply impossible.

Each tool provides a unique element for conducting risk assessments. It is therefore recommended that all three the risk assessment tools be used in the qualitative initial risk assessments, as this gives the researcher a more comprehensive estimation of the risks present in the hydrogeological environment.

5.3 Quantitative assessments

5.3.1 Preamble

The Environmental Risk Assessment and URA methodologies are not spatially based. On the other hand the DRASTI is spatially based, but only considers the aquifer vulnerability. In order to develop a more comprehensive approach, spatially based models were considered as discussed in the sections below.

5.3.2 Model assumptions and limitations

It is important to note that a numerical model is only an approximation of the natural environment and is dependent on the level of accuracy and quality of the data sets. There are always errors associated with groundwater models, due to a level of uncertainty in the data and as the capability of the software program to describe the natural environment accurately.

The following assumptions were made in order to develop the model:

- The top of the aquifer is represented by the surface topography and available surface elevations (50 m DTM data in this case) were used to construct a representative spatial extent;
- The available geology/hydrogeological data are sufficient to describe the natural environment;
- The available chemistry and groundwater level data were considered acceptable;
- Many aquifer parameters have not been determined (i.e. aquifer abstraction capabilities) and was estimated;

- The system is in equilibrium (even if the natural environment was disturbed in the past); and
- The boundary conditions were chosen on surface water drainage and the basis of geological sensitivity to possible impacts from surface activities.

5.3.3 Model construction

The model construction was based on the limited data available (from literature and collected) for the site area. Two models were developed and discussed in the following sections.

5.3.3.1 Analytical element modelling

A total model area of 2 313.3 km^2 was used for the modelling area. The western, north western and northern boundaries were chosen based on the geologic divide between dolomites (Malmani Formation) and the Witwatersrand Formations. This boundary was used as a no-flow boundary, with a portion of the boundary used as a flux boundary in the area of the Mooi River north of Potchefstroom where water flows into the modelling system.

The north eastern boundary was based on the natural topographical highs and was used as a no-flow boundary.

The eastern and south eastern boundary was also based on a geological contact divide between the dolomites and the lithologies of the Witwatersrand Formations and was used as a no-flow boundary, with a portion used as a flux boundary where there is inflow from the Vaal River.

Finally, the southern boundary was based on natural topographical highs and used as a flux boundary due to the outflow of the Vaal River from the modelling system.

Only one aquifer layer of a 30 m thickness was used (based on borehole geological log data) during the model construction due to capability constraints within the Visual AEM programming. An inhomogeneity element based on the alluvial geology was added to the modelling environment in order to determine the impacts on the alluvials from urbanisation.

It should be noted that no discretisation of the grid was necessary in this method of modelling.

Figure 5.2 graphically provides the model boundaries as well as the integrated geological and topographical environment on which the boundaries were based.

5.3.3.2 Numerical modelling

The exact same modelling environment was used during the construction of the numerical model in PMWin as described in Section 5.3.3.1 above. The flux boundaries applied in the analytical element model were replaced with general head boundaries.

A uniform grid of 100 x 100 m cells were constructed and then refined to 50 x 50 m cells around the study or town area where most of the detail and accuracy in computation were focused.

Figure 5.3 presents the model boundaries and modelling environment constructed in PMWin.

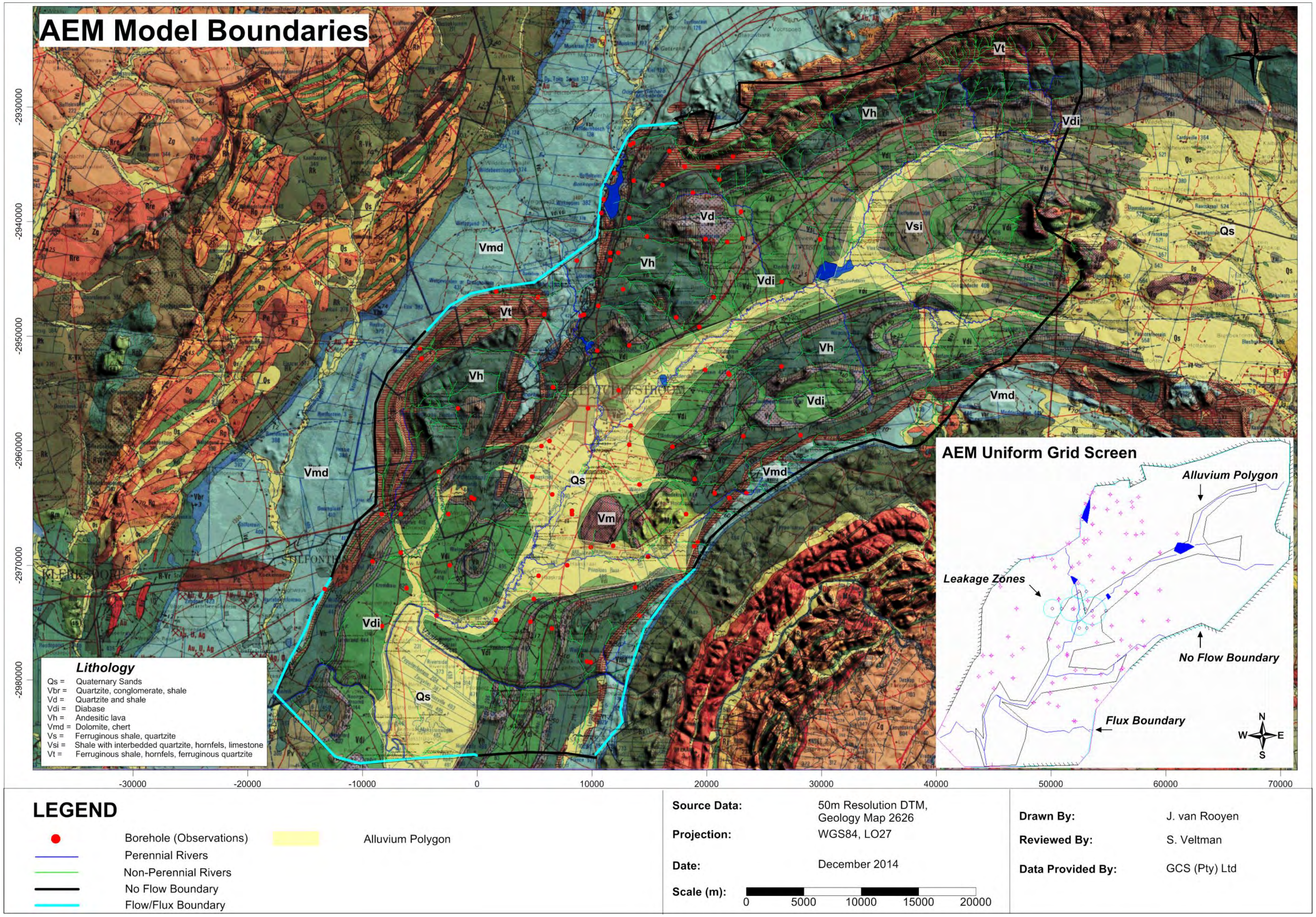
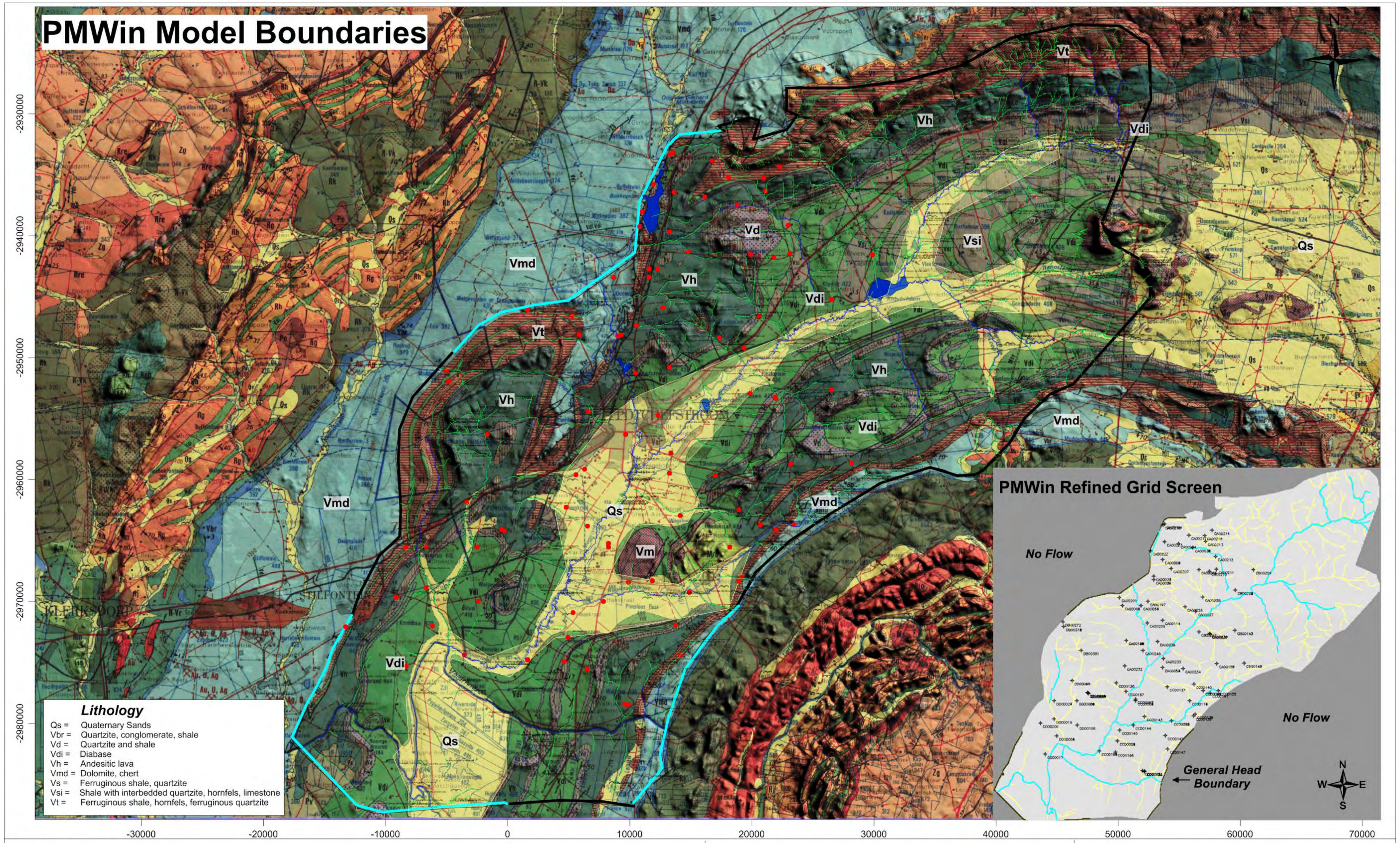


Figure 5.2: AEM model boundaries



LEGEND

Borehole (Observations)	Alluvium Polygon
Perennial Rivers	
Non-Perennial Rivers	
No Flow Boundary	
Flow/Flux Boundary	

Source Data:	50m Resolution DTM, Geology Map 2626
Projection:	WGS84, LO27
Date:	December 2014
Scale (m):	0 5000 10000 15000 20000

Drawn By:	J. van Rooyen
Reviewed By:	S. Veltman
Data Provided By:	GCS (Pty) Ltd

Figure 5.3: PMWin model boundaries

5.3.4 Aquifer parameters

Many of the aquifer parameters were calculated or assumed due to data limitations and understanding of the natural environment.

5.3.4.1 Analytical element modelling

The Visual AEM software contains within it an existing database of geological and hydrogeological parameters for setting up a model if parameters are unknown or cannot be calculated. The values in the database were adapted from Freeze & Cherry (1979:145-166).

The elemental input into the model comprises the various river systems within the modelling area as well as the Boskop and Potch Dams (as main lakes). The recharge flux was derived from the calculated recharge percentage and converted from mm/a to mm/d.

Leakage zones were identified based on locality and each zone was assigned a fractional value of the total recharge flux namely:

- Residential areas – uniform leakage (0.0000165 m/d); and
- The CBD and industrial area – uniform leakage (0.0000331 m/d).

One inhomogeneity element was inserted for the alluvium (polygonal) location with values of a fractured non-sedimentary medium (0.173 m/d).

Table 5.5 presents the aquifer parameters used for input into Visual AEM.

5.3.4.2 Numerical modelling

The model constructed in PMWin was assigned the same values for each parameter as given in the AEM model (Table 5.5).

Table 5.5: Aquifer parameter summary

Parameters	Description	Comments	Assigned values
Primary aquifer & inhomogeneity element	Alluvial	Thickness: 30 m	0.000865 m/day
Secondary aquifer	Fractured non-sedimentary	(Not modelled)	0.173 m/day
Recharge	Recharge flux	4 % of MAP	0.0000661 m/day
Rivers	AEM rivers	Elevation controlled	
	Rivers (PMWin) - Mooi River	100 m cells	5 m/day
	Rivers (PMWin) - Mooi River	50 m cells	2.5 m/day
	Rivers (PMWin) - Vaal River	100 m cells	10 m/day
	Rivers (PMWin) - Vaal River	50 m cells	5 m/day
Dams (AEM)	AEM Lakes	Elevation controlled	
Drains	Non-perennial rivers (PMWin)	100 m cells	3.75 m/day
	Non-Perennial Rivers (PMWin)	50 m cells	1.8 m/day
	Leakage zones	Residential areas	0.0000165 m/day
	Leakage zones	CBD & industrial areas	0.0000331 m/day
Head observations	Water levels	All boreholes available	

5.3.5 Model outcome

5.3.5.1 Analytical element modelling

During initial construction the input elements i.e. boundaries, recharge and rivers were digitised precisely on the assumption that the more information added will provide more accurate convergence. It was discovered that the program could not manage with too much input detail as the model was built to function on averages. Thereafter the model construction was simplified with less detail.

It was discovered that uniform recharge could not be applied over inhomogeneous areas in Visual AEM. This resulted in the model not converging properly.

When the model solve command was engaged and successful convergence was achieved, the model results could not be viewed. A 'Runtime Error' would appear and automatically terminate the program without the option to save.

Therefore a decision was made to abandon the approach.

5.3.5.2 Numerical modelling

Unlike the elementary approach of the AEM model, the calculations within PMWin are much more complex and thus the construction of the model was constructed with precision. However the model could not be brought to steady state calibration due to data deficiency. The existing data for input into the numerical model i.e. time series water levels and time series hydrochemistry data was only available for areas outside the area of investigation.

After running the model, the results only showed one borehole with sufficient data and when plotted on the comparison plot between the calculated and observed heads, the location of the borehole in relation to the line (Figure 5.4) indicated that the assigned values were too high.

However, when a 2D visualisation tool for head observations was extracted, the model showed that various areas within the model had dried up. Therefore, should parameter values be further decreased, the chances of increased dewatering will result.

Therefore once again a decision was made to abandon the approach.

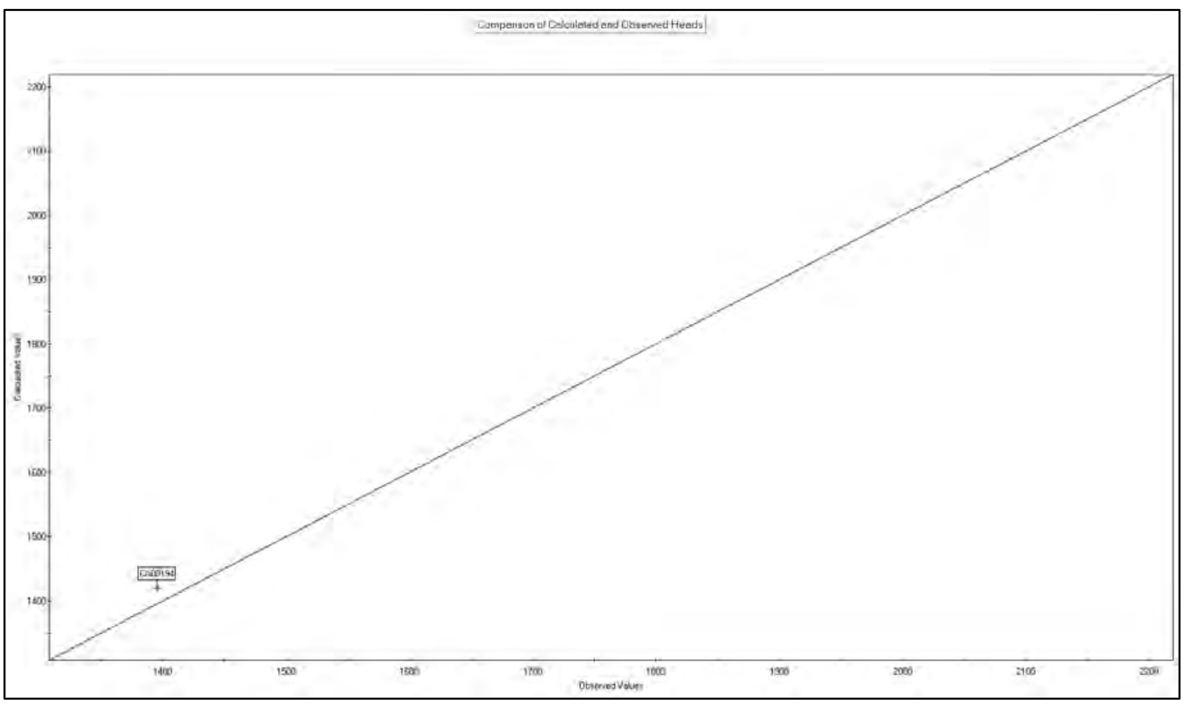


Figure 5.4: Calculated vs. observed plot

5.4 Conclusions

It is clear that the methodologies in this Chapter all have short comings and are therefore not suited for as a generic methodology to determine urban risk assessments in South Africa. Therefore it was deemed necessary to develop a spatially based, user-friendly methodology, especially for data-scarce areas. This methodology will be discussed in more detail in the next Chapter.

CHAPTER 6

6 QUANTIFICATION OF URBAN RISK

6.1 Preface

In this Chapter a step by step methodology is used to define and quantify the urban risks. Once again Potchefstroom, discussed in Chapter 4 will be used to demonstrate how the methodology works. As such the data collection process will not be repeated in this Chapter and the readers are referred to Chapter 4 for more detail.

6.2 Methodology (step by step)

6.2.1 Delineation of study area

After data has been collected and assessment, the study area must be delineated. For the purpose of this methodology, a smaller area was considered as that discussed in Chapter 5.

It was decided to limit the model extent to only the urban area as this will provide a more ideal modelling environment with fewer variables than those of the modelling methods previously tested (Chapter 5).

Natural boundaries are always used where possible for study area boundaries. Therefore the boundaries of the quaternary catchment C23H were used as the southern and eastern boundaries (Figure 6.1). There are 2 east-west dykes to the north of Potchefstroom as shown on the geological map and aerial magnetic map (Figure 6.2 and Figure 6.3). To ensure most of the town was included in the area, the northern most dyke was assumed as the northern boundary of the study area. The western boundary was selected as the geological contact between the dolomites and fractured hard rock aquifer. The resultant study area is shown in Figure 6.4, together with boreholes located within the area.

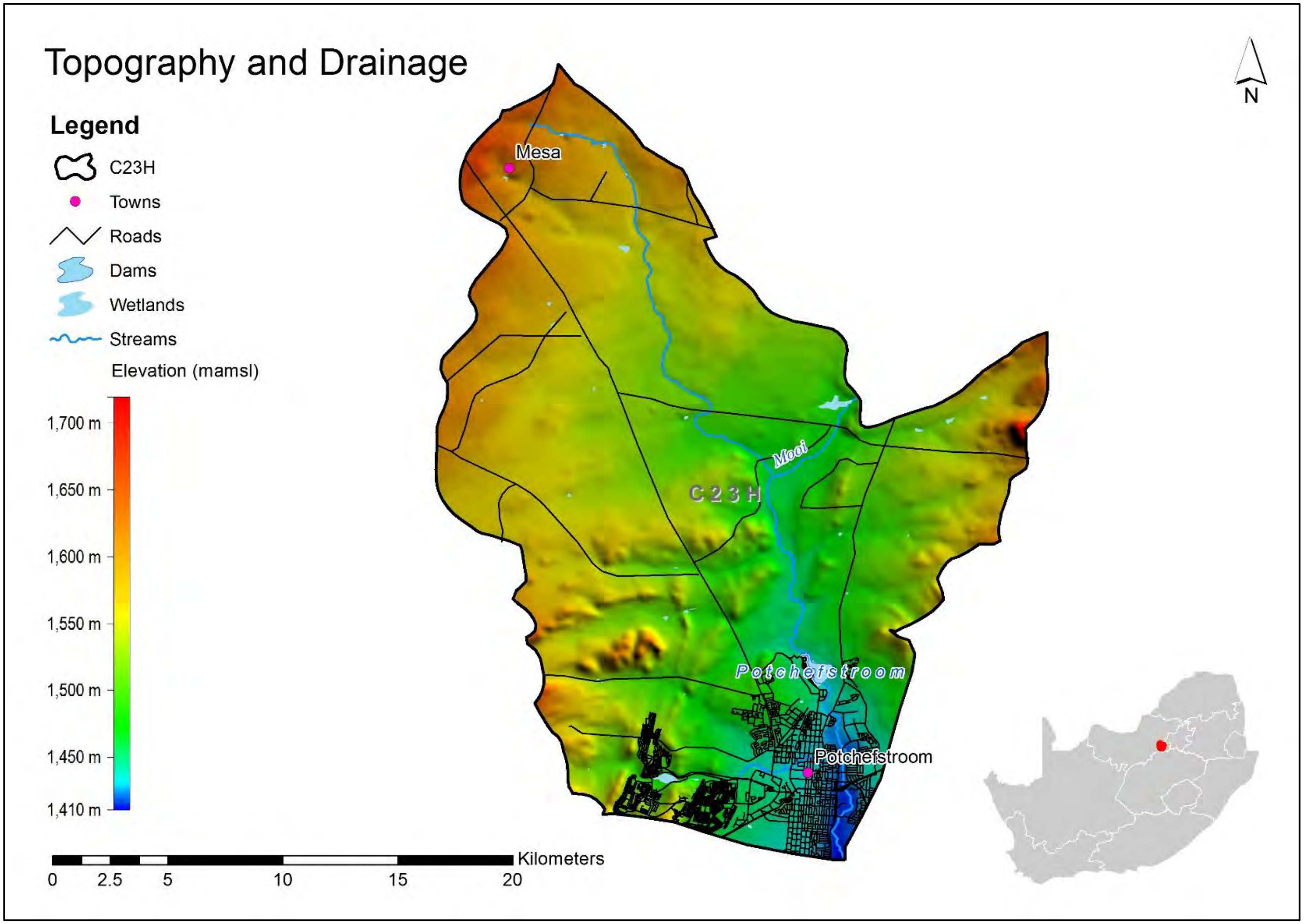


Figure 6.1: Quaternary catchment

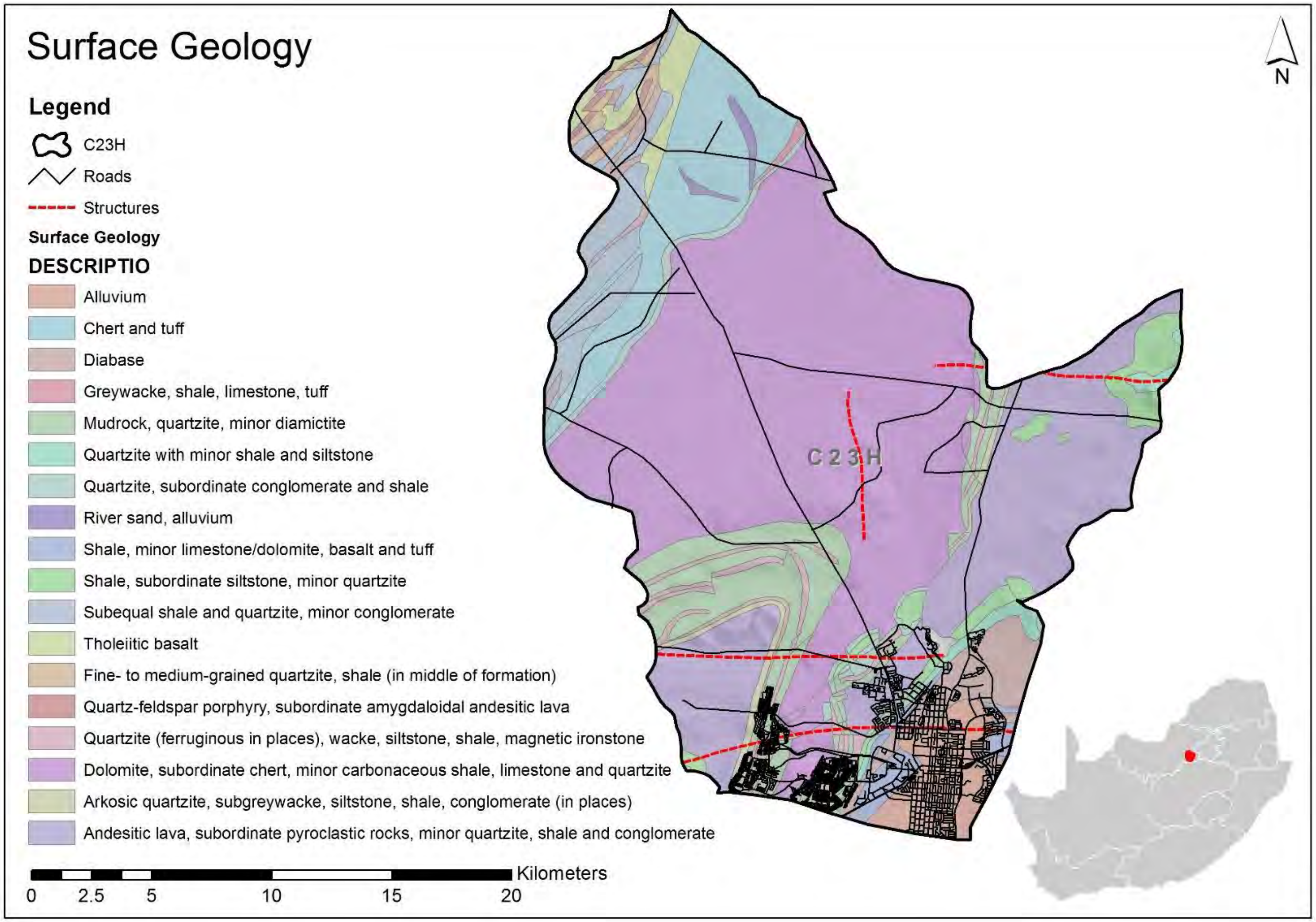


Figure 6.2: Geology (obtained from Council for Geoscience)

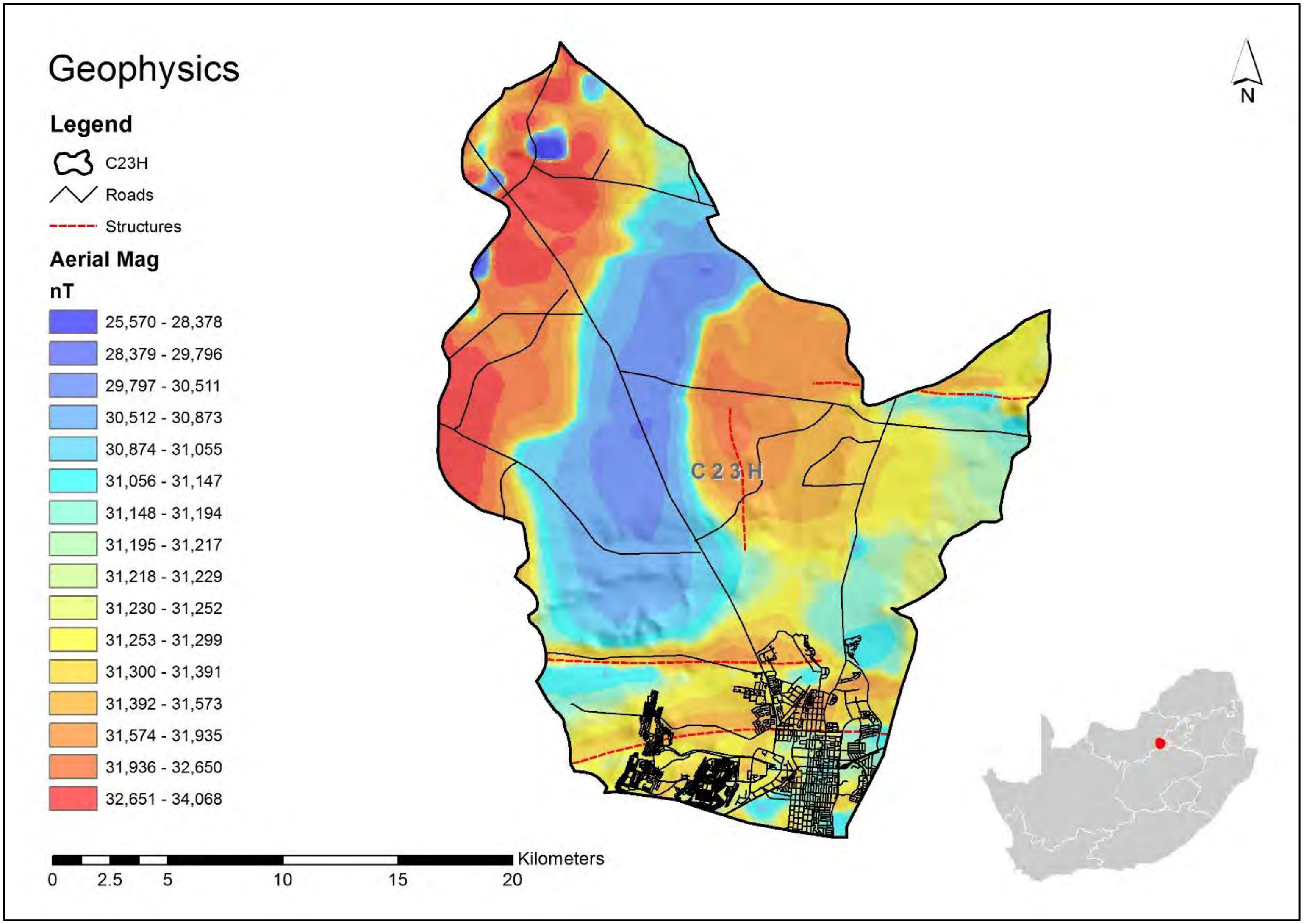


Figure 6.3: Aerial magnetic map (obtained from Council for Geoscience)

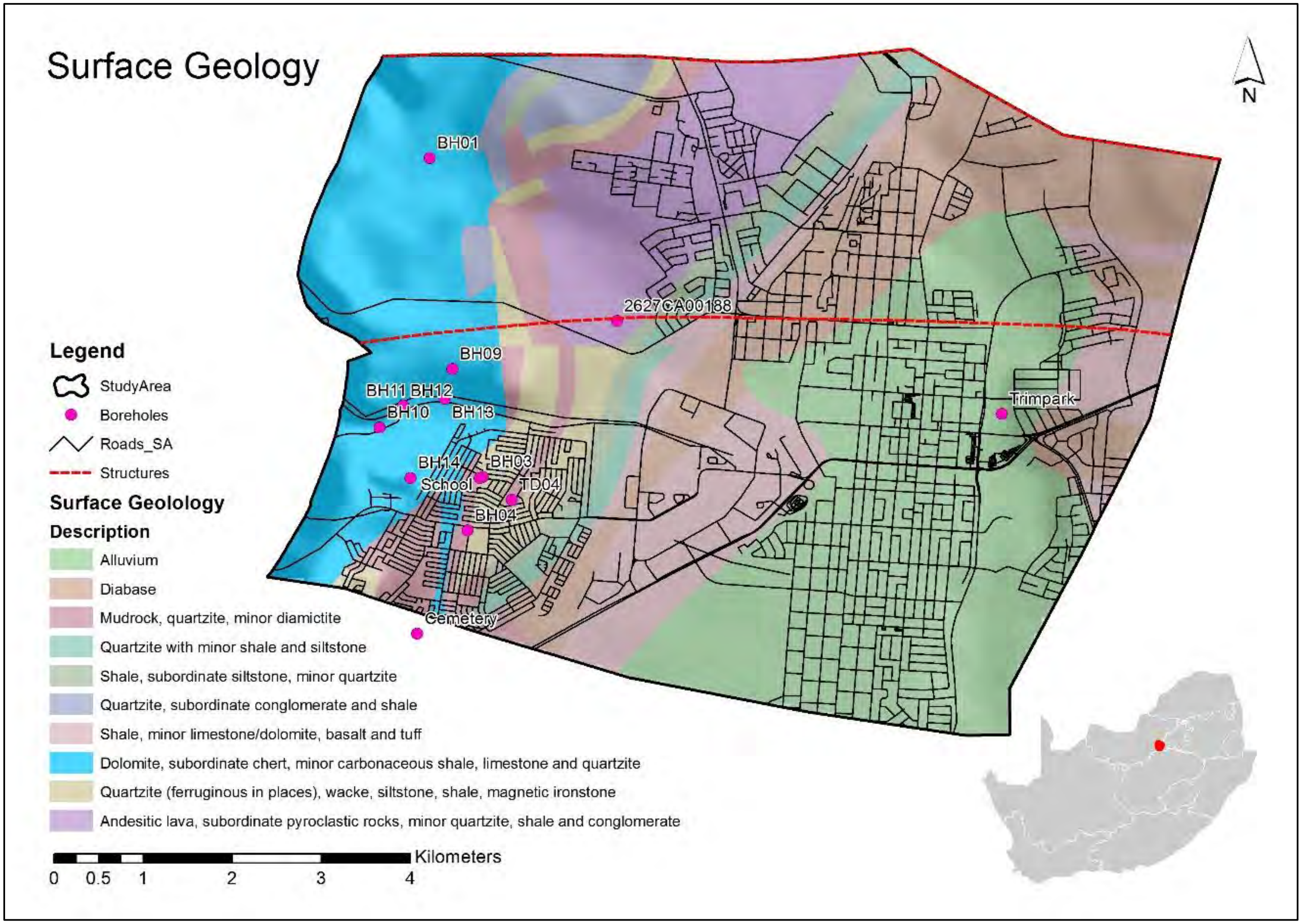


Figure 6.4: Study area

6.2.2 Generation of water levels

There are a few boreholes in the dolomites, a few in the fractured hard rock and only one in the alluvium. As in Chapter 4, groundwater levels were plotted against surface elevation as shown Figure 6.5 and Figure 6.6 to obtain a correlation. The results indicate a good correlation for the fractured hard rock but a poor correlation for the dolomites. Therefore Bayesian interpolation was used to generate groundwater levels over the fractured hard rock and Kriging interpolation was used to generate water levels over the dolomites (Figure 6.7).

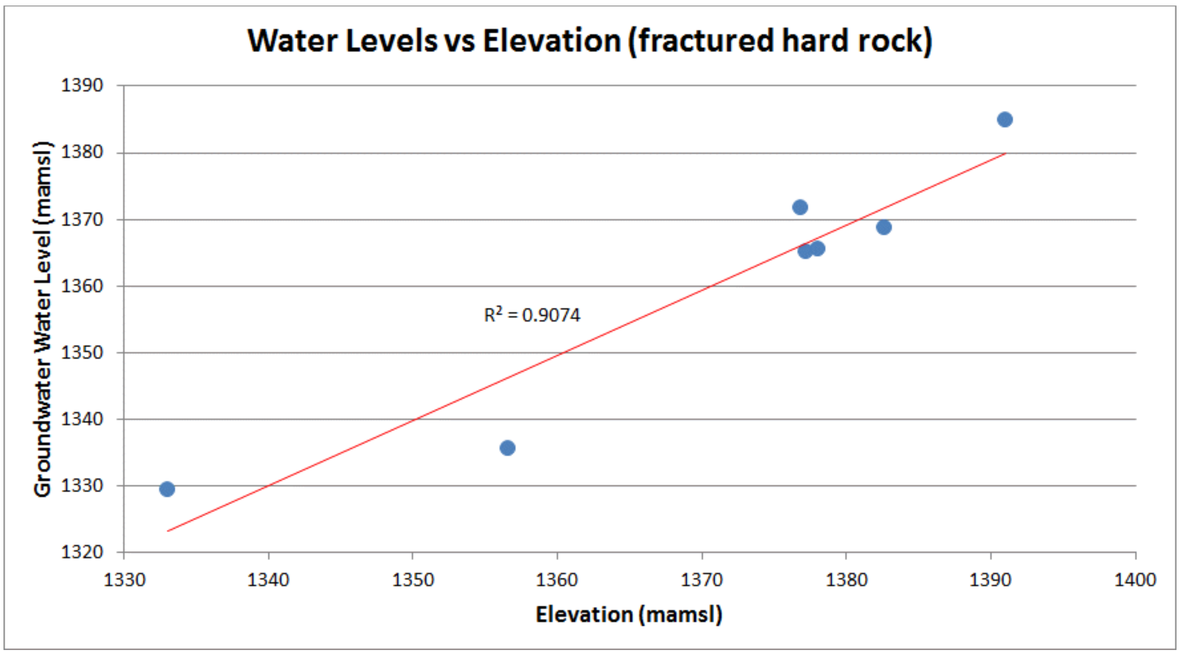


Figure 6.5: Correlation (fractured hard rock)

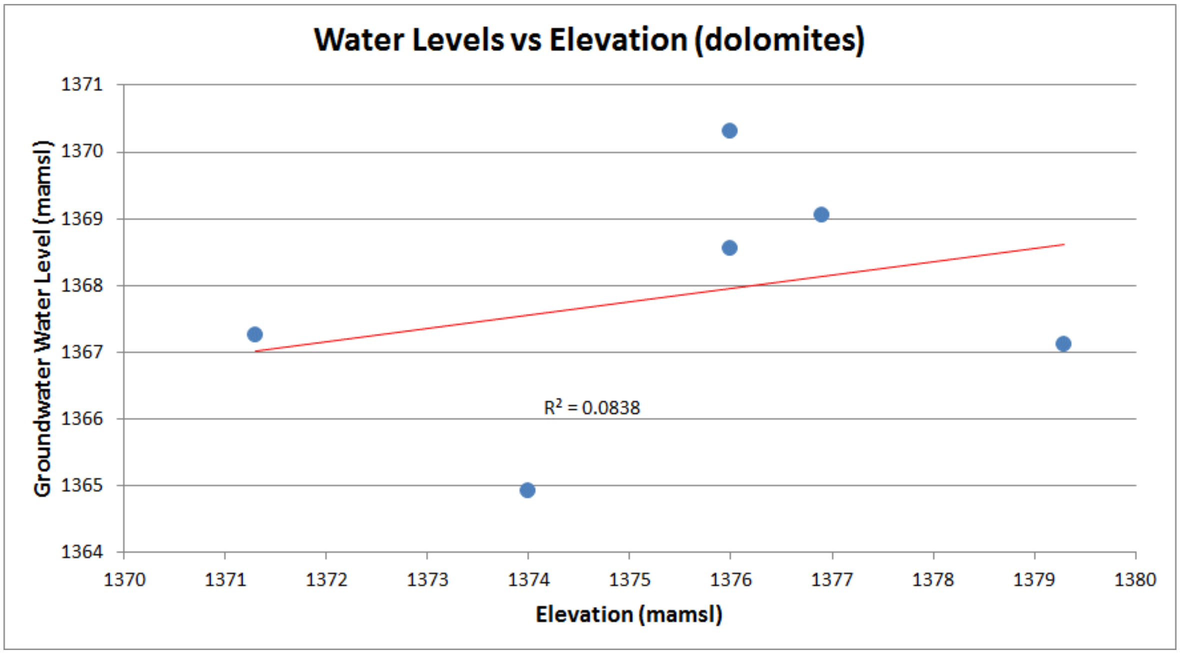


Figure 6.6: Correlation (dolomites)

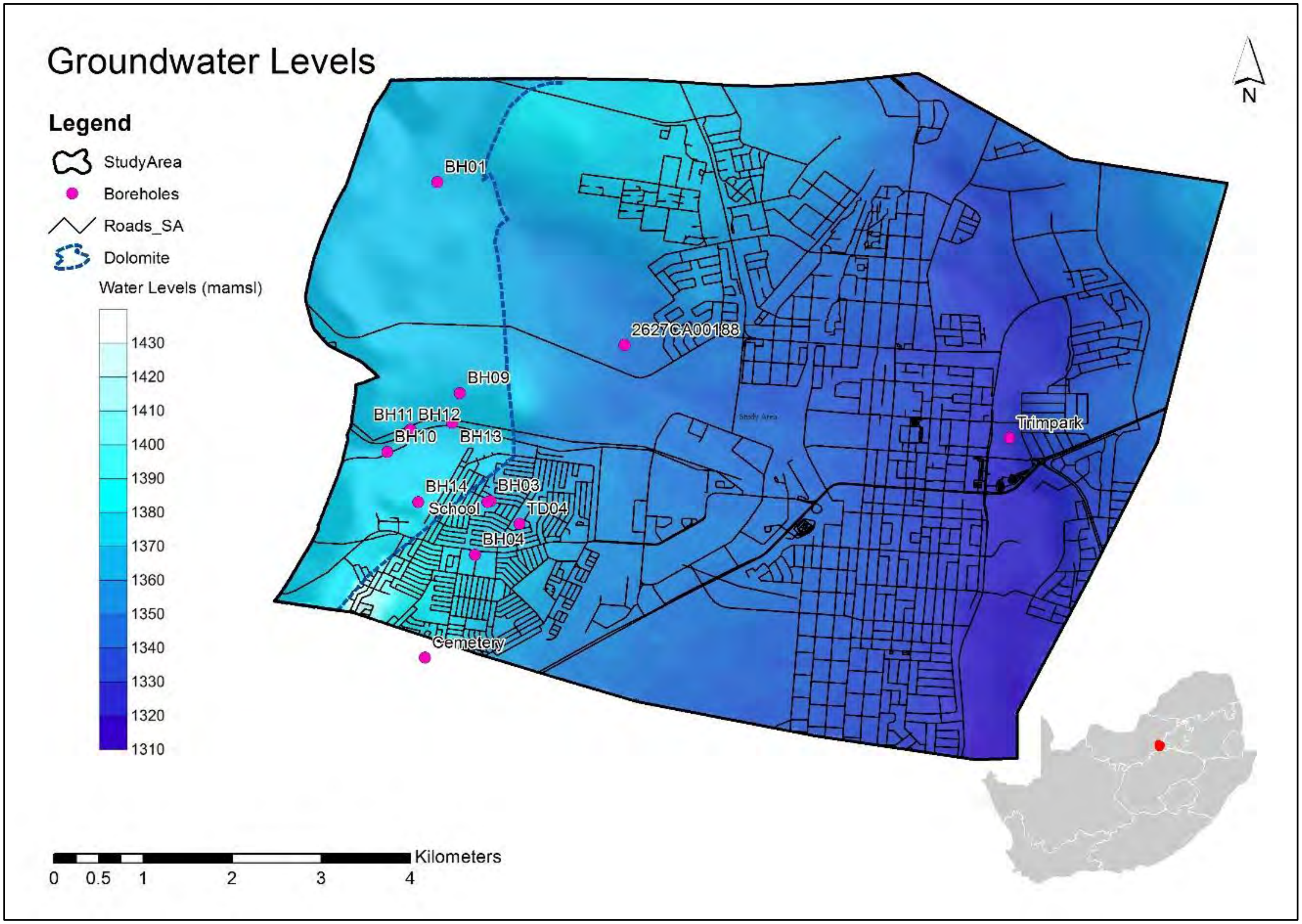


Figure 6.7: Groundwater levels

6.2.3 Water balances

6.2.3.1 Approach

The system in question will be modeled through a water balance approach. Both a surface water and groundwater balance model are employed and linked through the common recharge component present in each model. The general components for the aforementioned models are presented in Figure 6.8.

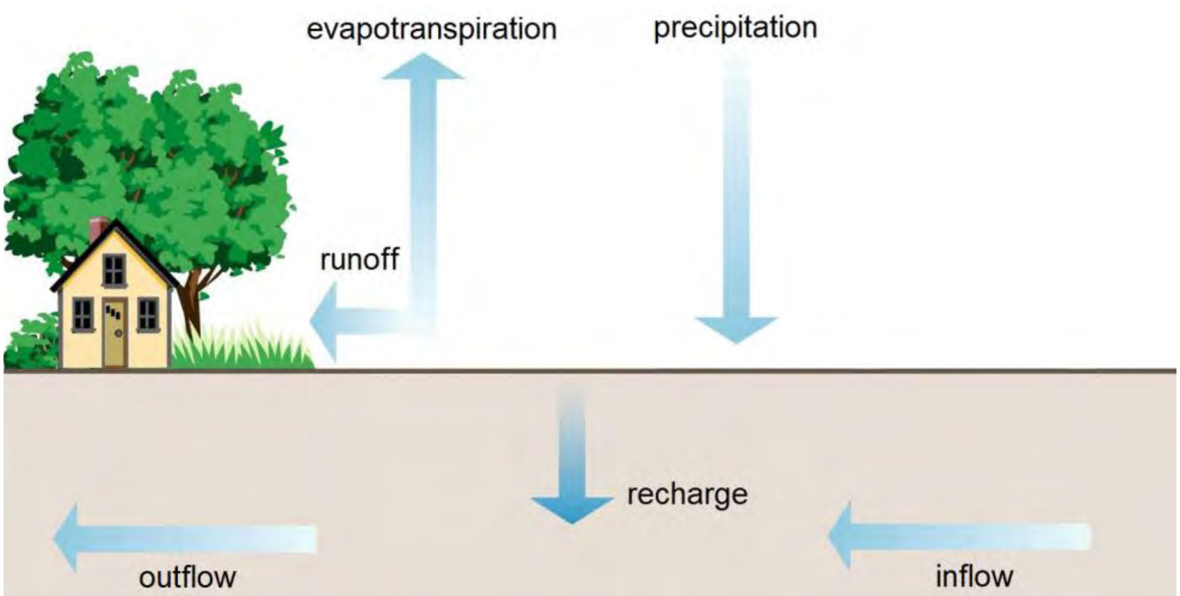


Figure 6.8: General water balance components

6.2.3.2 Groundwater balance

The general groundwater balance is defined as follows:

$$\Delta S = R_E + Q_{inflow} - Q_{outflow} \tag{1}$$

Where,

ΔS = *Change in storage*

R_E = *Effective Recharge*

Q_{inflow} = *Sum of all groundwater inflows*

$Q_{outflow}$ = *Sum of all groundwater outflows*

The change in storage in Equation 1 can be translated into a change in head in the aquifer through the use of the specific yield of the system and considering the surface area of the aquifer as presented in Equation 2.

$$h_i = h_{i-1} + \frac{R_E}{S_y} + \frac{Q_{inflow} - Q_{outflow}}{A \times S_y} \quad (2)$$

Where,

h_i	=	*Head in current month*
h_{i-1}	=	*Head in previous month*
R_E	=	*Effective Recharge*
S_y	=	*Specific Yield*
A	=	*Aquifer surface area*
Q_{inflow}	=	*Sum of all groundwater inflows*
$Q_{outflow}$	=	*Sum of all groundwater outflows*

6.2.3.3 Surface water balance

The general surface water balance (Figure 6.8) is defined as follows:

$$P = Q + E_T + R_E \quad (3)$$

Where,

P	=	*Precipitation*
Q	=	*Runoff*
R_E	=	*Effective Recharge*
E_T	=	*Evapotranspiration*

In general the precipitation value and estimates of evapotranspiration is known for the Equation 3. The effective recharge can be calculated through the use of a groundwater balance model e.g. the SVF (cited by van Tonder & Xu, 2001:4).

The SCS (Soil Conservation Services) (cited by Haan *et al*, 1994:63), developed the concept of a curve number to account for infiltration, to estimate storm flow from rainfall events. The storm flow is given as:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \tag{4}$$

$$S = \frac{25400}{CN} - 254 \tag{5}$$

Where,

P	=	*Precipitation*
Q	=	*Runoff*
S	=	*Retention Value*
CN	=	*Curve Number*

The retention *S* is a function of the following five factors and is reflected in the curve number (*CN*):

- Land use
- Interception
- Infiltration
- Depression
- Storage
- Antecedent moisture

Substituting Equation 4 in Equation 3, an expression for recharge is obtained as shown in Equation 6.

$$R = P - E_T - \frac{(P - 0.2S)^2}{P + 0.8S} \tag{6}$$

$$R \neq R_E \tag{7}$$

Since P and E_T are known, R becomes a function of S. The retention S is related to land cover and hydrological soil group via the curve number for storm conditions which occurs on an hourly time scale. Groundwater recharge is typically expressed as an annual average and therefore S would yield incorrect effective recharge values.

For the purposes of this study the curve number definition will not be changed and remain as defined by the Soil Conservation Services. To equate Equation 6 to effective recharge, proportionality constant C_{fit} is introduced.

$$R_E = P - E_T - C_{fit} \times \left[\frac{(P - 0.2S)^2}{P + 0.8S}\right] \quad (8)$$

Equation 8 refers to the recharge over an area represented by a single curve number. Equation 8 can be extended to accommodate a range of curve numbers based on the relative area they occupy (Equation 9).

$$R_E = P - E_T - \sum_{i=1}^{n} \left\{C_{fit} \times \left(\frac{A_i}{A_{tot}}\right)\left[\frac{(P - 0.2S_i)^2}{P + 0.8S_i}\right]\right\} \quad (9)$$

Where,

P	=	*Precipitation*
R_E	=	*Effective Recharge*
E_T	=	*Evapotranspiration*
C_{fit}	=	*Proportionality Fitting Constant*
n	=	*Total number of land cover classes considered*
i	=	*Index*
S_i	=	*Retention value i*
A_{tot}	=	*Total Area*
A_i	=	*Area value i*

6.2.3.4 Results of SVF calculations

The SVF groundwater balance was applied to both the fractured hard rock system and the dolomitic system. The results of the calibration are shown in Figure 6.9 and the parameters are summarised in Table 6.1.

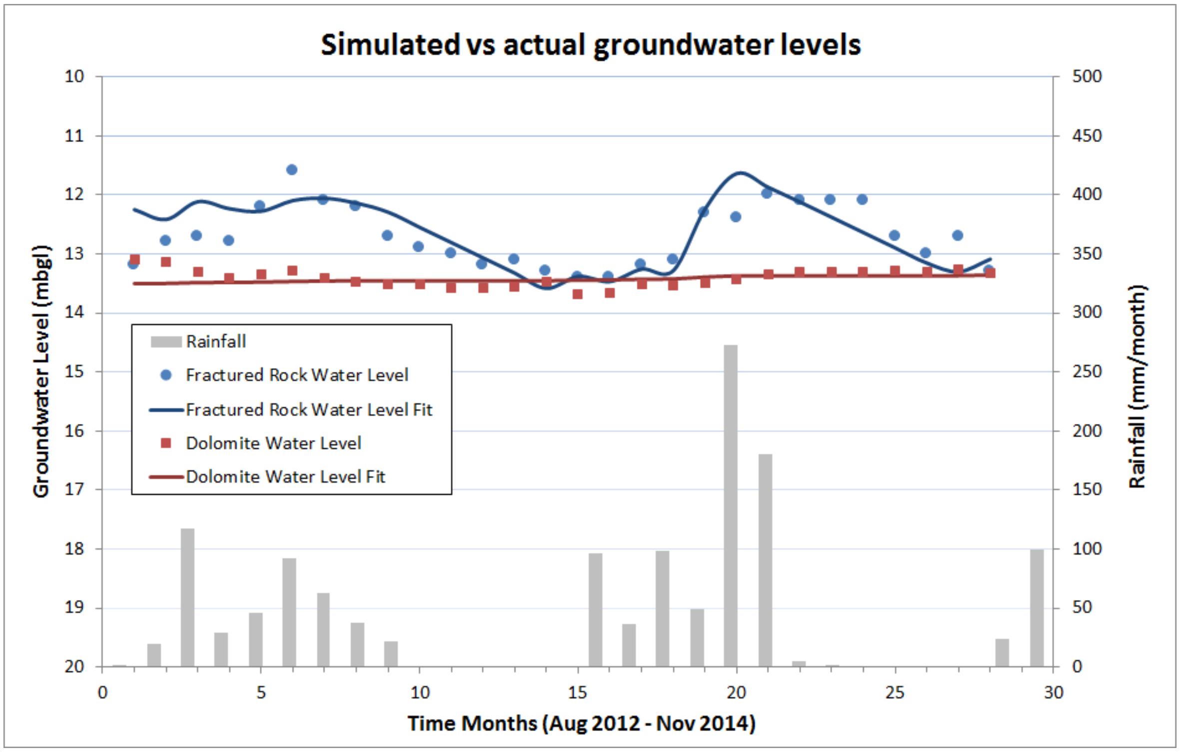


Figure 6.9: Results of SVF groundwater balance

Table 6.1: Groundwater balance results

Fractured rock			**Dolomite**		
Monthly inflow (m^3)	**Monthly outflow (m^3)**	**Recharge (m^3)**	**Monthly inflow (m^3)**	**Monthly outflow (m^3)**	**Recharge (m^3)**
151984	180000	64276	0	500	45231

The model was calibrated with the following parameters:

- Specific yield (Fractured rock) = 0.015
- Specific yield (Dolomite) = 0.15
- Recharge (Fractured rock) = 3% of MAP
- Recharge (Dolomite) = 12% of MAP

6.2.3.5 Results of the modified surface water balance calculations

Curve numbers were selected for the land cover and associated hydrological soils for both the dolomitic and fractured rock aquifer. The selected curve numbers are presented in Table 6.2 and Table 6.3 respectively.

Table 6.2: Dolomitic aquifer curve number selection

Land cover	*Curve Number*		*S*	
Class	*B/C*	*C*	*B/C*	*C*
Natural Grassland	75	79	84.7	67.5
Cultivation	79	83	67.5	52.0
Residential 1	80	83	63.5	52.0
Residential 2	88	90	34.6	28.2
Industrial	90	91	28.2	25.1
Mining	88	90	34.6	28.2
Roads	98	98	5.2	5.2

Table 6.3: Fractured rock aquifer curve number selection

Land cover	*Curve Number*		*S*	
Class	*B/C*	*C*	*B/C*	*C*
Natural Grassland	75	79	84.7	67.5
Cultivation	79	83	67.5	52.0
Residential 1	80	83	63.5	52.0
Residential 2	88	90	34.6	28.2
Industrial	90	91	28.2	25.1
Mining	88	90	34.6	28.2
Roads	98	98	5.2	5.2

The E_T values used are shown in Table 6.4. Note that only natural grassland, cultivation and residential 1 land cover classes were assigned E_T values.

Table 6.4: Evapotranspiration values used for land cover classes

Landcover Class	*ET* *mm/d*	*m/month*
Natural Grassland	1.50	0.0450
Cultivation	5.40	0.1620
Residential 1	1.65	0.0495
Residential 2	0.00	0.0000
Industrial	0.00	0.0000
Mining	0.00	0.0000
Roads	0.00	0.0000

The model was balanced using the current land cover with the following parameters:

- MAP = 607 mm/a
- Recharge (Fractured rock) = 3.3% of MAP
- Recharge (Dolomite) = 12% of MAP
- C_{fit} = 0.2

The impacts of the urbanisation was removed by changing the land cover to just that of natural grass land which led to the following results as shown in Table 6.5.

Table 6.5: Recharge comparison of pre- and post-urbanisation

Land cover	*Dolomitic Recharge*	*Fractured Rock Recharge*
Pre-urbanization	10.3% of MAP	3.6% of MAP
Post-urbanization	12% of MAP	3.3% of MAP

The model results show that the effect of urbanisation on the dolomitic aquifer has increased the effective recharge leading to more shallow water levels which increase the aquifer vulnerability with respect to the occurrence of surface pollution which could migrate to the groundwater.

The converse is true for the fractured rock aquifer which exhibits a decrease of recharge due to urbanisation which will lower the groundwater levels and in turn be less vulnerable to the possibility of surface pollution migrating to the subsurface.

6.2.4 Urban risk assessment calculation

The URA (WRC, 2004a) lowest tier methodology was included in the current methodology. This assessment uses professional judgement and considers only 3 factors for source evaluation:

- Source: this allows the contaminant sources classified by danger rating of high, medium or low. These ratings come directly from the national ranking of sources discussed in WRC (2004a)
- Estimated number of similar sources within study area. The following rating is used:
    - 1 – 5 sources : low rating
    - 5 – 10 sources : medium rating
    - Greater than 10 sources : high rating
- Level of management at the source:
    - Exceptional level of management is given a low rating
    - Average level of management is given a medium rating
    - Unsatisfactory level of management is given a high rating

Contaminants related to the sources can also be evaluated taking the following into account:

- Fate of the contaminant in the environment;
- Health impacts related to the contaminant; and
- Prioritisation of the source.

A fuzzy logic approach as discussed in Chapter 2 is then applied to determine the risks. Examples of typical sources for the Potchefstroom area are shown in Figure 6.10, together with the aquifer vulnerability index as defined in Chapter 2. The urban risks were calculated for the expected current conditions in the Potchefstroom area.

Contaminants which display the highest risk are shown in Figure 6.11.

The total urban risk assessment is shown in Figure 6.12.

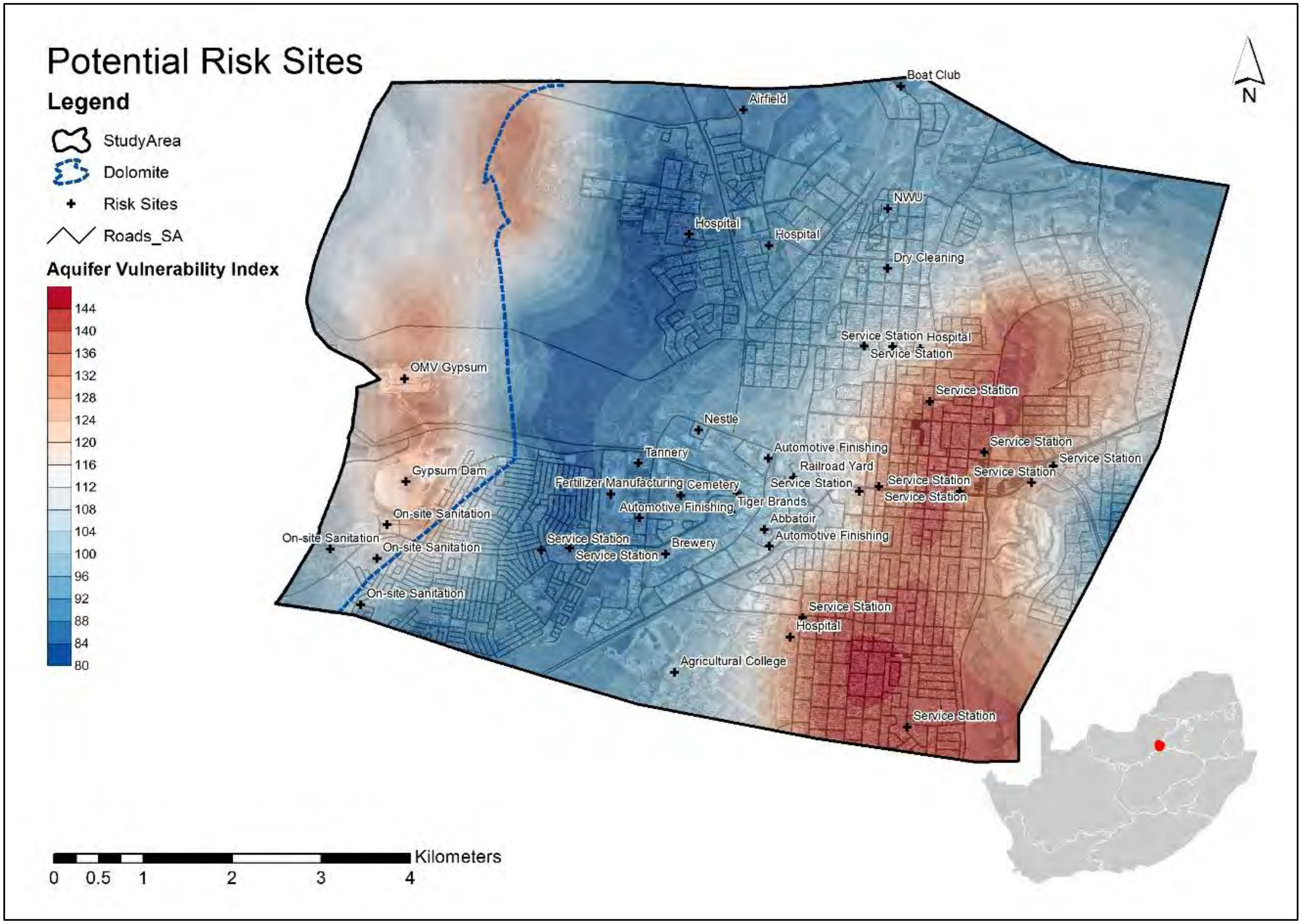


Figure 6.10: Sources of contamination

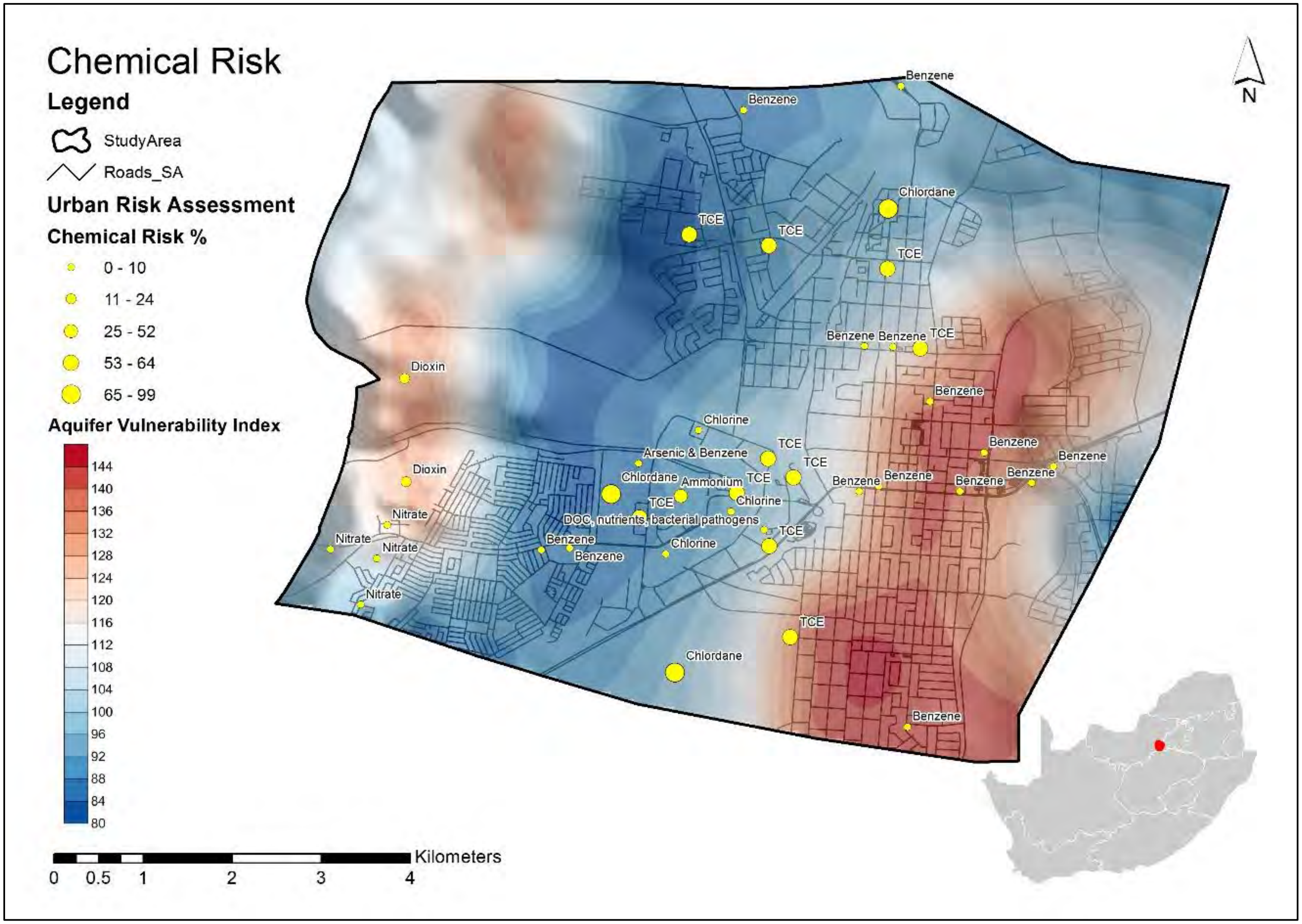


Figure 6.11: Highest risk contaminants

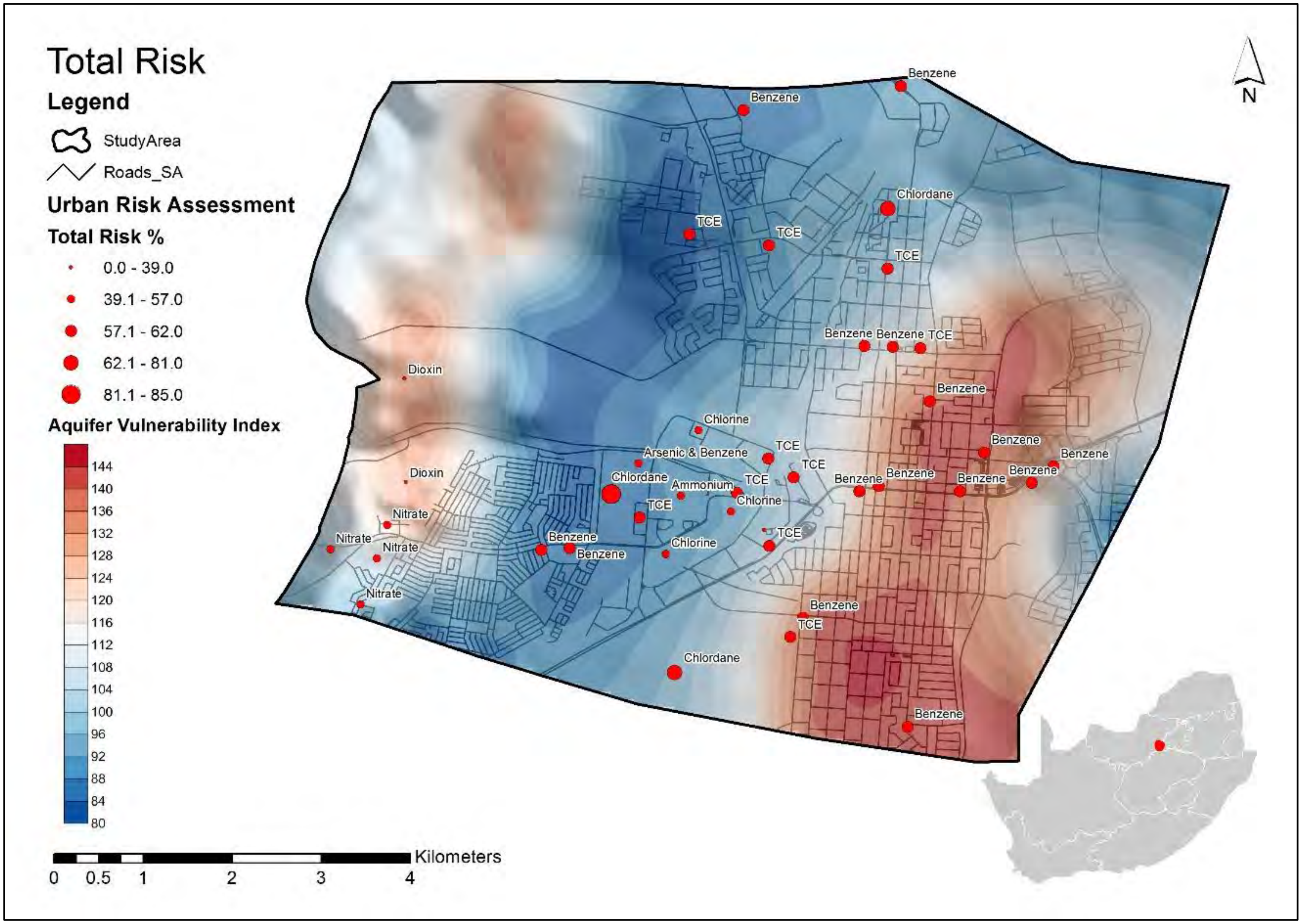


Figure 6.12: Total urban risk

CHAPTER 7

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The greatest challenge faced with during this investigation was the minimalistic data availability for the study area.

The conceptualisation and qualitative site impact assessments focused on any environmental changes observed in available groundwater levels, groundwater quality as well as available flow gauge chemistry.

The source-pathway receptor principle was applied to the development of the conceptual model.

Different qualitative risk assessment approaches were compared as part of the qualitative risk assessments. In addition AEM and finite difference models were developed, the aim thereof was to determine the most effective way to calculate the risks associated with urbanisation. Numerous problems were experienced, many due to the lack of data. It was therefore necessary to develop a new methodology which is spatially and temporally based, and can be applied even when data is sparse. The workings of this methodology were demonstrated using Potchefstroom as a case study.

The new risk quantification methodology for urbanisation incorporated logical steps and associated processes to serve as a guide for future urban hydrogeological investigations. The methodology was constructed in such a way that it could assist in the application of the correct processes and methods depending on the complexity of the problem as well as to provide a guideline of thought processes during the decision-making process.

The results show that the effect of urbanization on the dolomitic aquifer has increased the effective recharge leading to more shallow water levels which increase the aquifer vulnerability with respect to the occurrence of surface pollution which could migrate to the groundwater.

The converse is true for the fractured rock aquifer which exhibits a decrease of recharge due to urbanization which will lower the groundwater levels and in turn be less vulnerable to the possibility of surface pollution migrating to the subsurface.

The highest urban risk is as a result of Chlordane from the manufacturing of fertilisers.

7.2 Recommendations

The following recommendations are proposed for future studies in the urban hydrogeological field:

- Long term studies addressing the risks and impacts on the receiving environments localised in urbanised areas are required;
- Local governments must be made aware of the necessity to incorporate such investigations into the budgets of urban planning;
- Monitoring of the following:
    - Water balances and water flow – for example recharge or infiltrating rainfall into impermeable surfaces;
    - Contaminant concentrations distributions over time as well as contaminant loads; and
    - Boreholes in strategic locations of the urban area in order to obtain sufficient information across the entire extent.
- Identification of likely contaminant sources within the urban area to lower the risk of long term exposure of contaminants to the receiving environment;
- Once sufficient data has been collected, numerical modelling should be done to give a more accurate representation of the natural environment and to simulate potential pollution plumes, if any as well as to determine the surface water and groundwater interactions;
- Quantitative risk assessments based on the numerical modelling results will give a better indication of areas that will need immediate attention for mitigation; and
- Installation of monitoring boreholes in key areas within the urban environment – for example in some residential areas, some at petrol and diesel stations (to monitor the hydrocarbons) and some in the industrial areas to monitor discharged effluent.

CHAPTER 8

8 REFERENCES

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APPENDIX A

NGDB BOREHOLES

BH ID	Date measured	Coordinated (WGS84, LO27)		Elevation	SWL
		X	Y	(50 m DTM)	(mbgl)
2626DB00092	07/18/1984	-14964.51	-2951748.46	1389	6.00
2626DB00093	07/26/1984	-14965.50	-2951750.67	1389	14.00
2626DB00094	04/09/1960	-14963.51	-2951748.45	1389	9.14
2626DB00095	04/22/1960	-14965.50	-2951751.78	1389	6.10
2626DB00096	05/02/1960	-14962.52	-2951748.45	1389	15.24
2626DB00107	06/17/1960	-14965.49	-2951758.43	1389	9.14
2626DB00109	05/14/1960	-14965.49	-2951759.54	1389	21.34
2626DB00110	06/10/1960	-14955.55	-2951748.45	1389	12.19
2626DB00111	07/02/1960	-14965.49	-2951760.65	1389	12.19
2626DB00113	11/21/1977	-14965.49	-2951761.75	1389	30.00
2626DB00131	07/25/1957	-16615.42	-2958151.39	1362	16.76
2626DB00132	08/08/1957	-16616.41	-2958152.50	1362	9.14
2626DB00133	08/14/1957	-16614.43	-2958151.39	1362	3.96
2626DB00134	10/26/1962	-16616.41	-2958153.60	1362	11.28
2626DB00135	11/15/1962	-16613.43	-2958151.39	1362	8.23
2626DB00136	12/06/1962	-16616.41	-2958154.71	1362	21.34
2626DB00137	01/12/1963	-16612.44	-2958151.38	1362	24.99
2626DB00140	07/01/1964	-16616.41	-2958156.93	1362	2.74
2626DB00142	07/28/1956	-16616.41	-2958158.04	1362	11.28
2626DB00146	07/21/1951	-16616.40	-2958160.25	1362	18.29
2626DB00149	02/02/1954	-16606.47	-2958151.38	1362	13.56
2626DB00150	02/13/1954	-16616.40	-2958162.47	1362	26.52
2626DB00151	02/24/1954	-16605.47	-2958151.37	1362	14.02
2626DB00152	06/30/1956	-16616.40	-2958163.58	1362	12.80
2626DB00154	06/29/1951	-16616.40	-2958164.68	1362	21.95
2626DB00177	11/30/1980	-19792.23	-2959326.00	1377	9.00
2626DB00272	06/15/1978	-5011.99	-2951063.65	1414	6.00
2626DB00278	12/05/1958	-11649.21	-2947065.97	1399	0.01
2626DB00283	06/12/1959	-9993.19	-2943371.67	1400	12.19
2626DB00284	06/24/1959	-9995.18	-2943375.00	1400	13.11
2626DB00285	01/19/1960	-9992.20	-2943371.67	1400	9.14
2626DB00286	01/27/1960	-9995.18	-2943376.11	1400	9.14
2626DB00287	05/09/1960	-9991.20	-2943371.67	1400	2.44
2626DB00288	05/18/1960	-9995.18	-2943377.22	1400	16.76
2626DB00289	06/03/1964	-9990.21	-2943371.67	1400	25.91
2626DB00290	06/04/1983	-9995.18	-2943378.32	1400	7.00
2626DB00292	07/30/1991	-8438.56	-2950621.16	1392	15.50
2626DB00294	07/30/1991	-15722.37	-2949835.88	1418	23.19
2626DB00298	07/30/1991	-6326.64	-2939673.14	1460	10.80
2626DB00300	07/30/1991	-852.09	-2936169.32	1456	2.10

BH ID	Date measured	Coordinated (WGS84, LO27)		Elevation	SWL
		X	Y	(50 m DTM)	(mbgl)
2626DB00301	07/31/1991	-8203.51	-2946169.14	1436	19.48
2626DB00312	05/14/1993	-4872.29	-2951955.53	1442	24.00
2626DB00314	04/29/1993	-4871.29	-2951955.53	1442	24.00
2626DB00318	03/31/1993	-4869.30	-2951955.52	1442	36.00
2626DB00365	03/01/1982	-9851.14	-2950604.45	1383	5.01
2626DB00367	03/01/1982	-12146.10	-2950175.43	1385	14.45
2626DB00368	03/01/1982	-12810.01	-2950268.05	1392	30.00
2626DB00369	03/01/1982	-12975.75	-2950761.27	1385	49.50
2626DB00374	03/01/1982	-16623.67	-2952611.43	1412	13.00
2626DB00380	03/01/1982	-11703.65	-2950666.96	1382	13.47
2626DB00381	03/01/1982	-1693.52	-2956294.69	1409	10.79
2626DD00008	09/22/1956	-3349.76	-2961836.10	1357	22.86
2626DD00015	02/25/1970	-3345.78	-2961835.00	1357	18.29
2626DD00017	06/03/1958	-8313.80	-2975317.33	1314	21.34
2626DD00018	12/05/1979	-6661.99	-2968884.32	1321	9.00
2626DD00019	09/24/1968	-8320.26	-2965532.48	1339	85.34
2626DD00020	10/17/1968	-8320.25	-2965533.58	1339	32.92
2626DD00021	12/05/1968	-8319.26	-2965531.37	1339	82.30
2626DD00024	03/22/1951	-6663.76	-2965530.39	1337	7.62
2626DD00025	04/07/1951	-6661.77	-2965529.28	1337	32.00
2626DD00027	12/07/1957	-6660.78	-2965529.28	1337	7.62
2626DD00029	03/16/1972	-6659.78	-2965529.28	1337	48.77
2626DD00030	08/10/1972	-6663.76	-2965533.71	1337	41.45
2626DD00050	11/23/1979	-11639.48	-2960920.27	1389	83.00
2626DD00054	06/12/1979	-6163.46	-2971993.15	1311	12.00
2626DD00055	06/16/1979	-6161.47	-2971992.04	1311	15.00
2626DD00056	06/19/1979	-6163.46	-2971994.26	1311	17.00
2626DD00058	08/22/1960	-2518.55	-2965527.77	1341	23.77
2626DD00061	08/09/1965	-2514.57	-2965529.99	1341	7.32
2626DD00064	09/16/1985	-2517.55	-2965527.77	1341	18.00
2626DD00066	11/19/1986	-2520.54	-2965527.77	1341	20.00
2626DD00067	01/09/1987	-2519.54	-2965533.31	1341	60.00
2626DD00089	10/22/1953	-504.17	-2964089.34	1367	13.72
2626DD00090	04/05/1955	-495.22	-2964080.48	1367	13.72
2626DD00091	04/16/1955	-504.17	-2964090.45	1367	15.24
2626DD00092	07/28/1960	-494.22	-2964080.48	1367	18.29
2626DD00093	04/07/1967	-504.16	-2964091.56	1367	39.62
2626DD00094	09/09/1971	-493.23	-2964080.48	1367	30.48
2626DD00100	08/28/1985	-490.24	-2964080.48	1367	24.00
2626DD00101	09/05/1985	-504.16	-2964095.99	1367	24.00

BH ID	Date measured	Coordinated (WGS84, LO27)		Elevation	SWL
		X	Y	(50 m DTM)	(mbgl)
2626DD00104	12/11/1986	-488.25	-2964080.48	1367	30.00
2626DD00106	08/14/1991	-2396.40	-2969979.72	1329	12.00
2626DD00158	02/23/1957	-13292.64	-2964672.48	1375	28.35
2626DD00161	04/20/1957	-13290.65	-2964672.48	1375	28.96
2626DD00162	09/08/1960	-13292.64	-2964674.70	1375	39.62
2626DD00166	07/10/1973	-14949.22	-2965536.37	1362	45.70
2626DD00167	09/28/1973	-14949.22	-2965537.47	1362	45.00
2626DD00172	02/26/1969	-13282.87	-2972059.58	1339	11.58
2626DD00173	03/13/1969	-13284.86	-2972062.91	1339	7.32
2626DD00185	06/30/1958	-13284.85	-2972069.56	1339	22.86
2626DD00206	01/14/1992	-9146.51	-2969654.84	1347	21.00
2626DD00208	06/20/1991	-13154.74	-2964364.32	1375	12.00
2627CA00008	03/15/1982	13254.06	-2939683.99	1411	12.00
2627CA00009	03/17/1982	13251.06	-2939687.31	1411	14.00
2627CA00011	01/23/1978	16746.86	-2933840.24	1497	44.00
2627CA00014	02/11/1956	8771.66	-2933801.26	1417	5.49
2627CA00015	04/14/1956	8771.42	-2934141.40	1415	60.05
2627CA00016	12/22/1956	8772.65	-2933801.26	1417	47.55
2627CA00017	01/13/1982	8771.42	-2934142.51	1415	40.00
2627CA00020	08/27/1956	11588.43	-2942731.51	1401	16.76
2627CA00021	09/04/1956	11590.42	-2942730.40	1401	16.76
2627CA00025	11/19/1955	11589.83	-2943375.24	1393	56.08
2627CA00027	01/10/1956	11590.83	-2943375.24	1393	57.91
2627CA00028	08/31/1957	11587.84	-2943378.56	1393	54.86
2627CA00029	05/02/1957	11591.82	-2943375.24	1393	24.38
2627CA00030	08/26/1968	11587.84	-2943379.67	1393	21.95
2627CA00031	03/23/1982	11592.82	-2943375.24	1393	30.00
2627CA00035	03/05/1969	18790.85	-2937504.91	1477	12.86
2627CA00036	03/26/1969	18791.85	-2937504.91	1477	22.56
2627CA00037	02/07/1977	18789.85	-2937506.02	1477	28.00
2627CA00038	03/23/1977	18789.85	-2937504.91	1477	5.00
2627CA00039	09/18/1985	18789.85	-2937507.13	1477	20.00
2627CA00043	03/02/1950	1627.17	-2946112.31	1432	12.19
2627CA00049	05/02/1984	3288.89	-2935676.67	1420	5.00
2627CA00050	05/07/1984	3291.88	-2935679.99	1420	6.00
2627CA00053	07/22/1968	13230.46	-2959474.78	1331	27.82
2627CA00054	04/10/1984	13232.45	-2959473.68	1331	19.00
2627CA00056	06/18/1956	19890.67	-2941539.60	1485	13.72
2627CA00057	07/16/1956	19891.67	-2941538.50	1485	28.96
2627CA00058	07/30/1956	19890.67	-2941540.71	1485	4.88

BH ID	Date measured	Coordinated (WGS84, LO27)		Elevation	SWL
		X	Y	(50 m DTM)	(mbgl)
2627CA00059	08/11/1956	19892.67	-2941538.50	1485	28.96
2627CA00063	06/21/1955	9288.53	-2948114.39	1353	12.19
2627CA00064	05/16/1957	9287.53	-2948113.28	1353	1.83
2627CA00068	05/01/1974	5858.47	-2948111.24	1388	6.00
2627CA00114	10/03/1984	13239.52	-2950788.13	1396	17.00
2627CA00121	01/18/1956	1630.95	-2939861.13	1416	27.43
2627CA00125	09/28/1957	1632.95	-2939861.13	1416	48.16
2627CA00130	01/08/1959	1627.96	-2939868.89	1416	33.83
2627CA00131	02/21/1958	1635.93	-2939861.14	1416	46.94
2627CA00132	03/01/1958	1627.96	-2939870.00	1416	18.29
2627CA00133	01/20/1958	1636.93	-2939861.14	1416	25.91
2627CA00135	02/12/1958	1637.93	-2939861.14	1416	41.45
2627CA00136	03/31/1958	1627.96	-2939872.21	1416	41.15
2627CA00137	04/14/1958	1638.92	-2939861.14	1416	0.01
2627CA00138	04/23/1958	1627.96	-2939873.32	1416	42.67
2627CA00139	10/08/1958	1639.92	-2939861.14	1416	6.10
2627CA00140	10/15/1958	1627.96	-2939874.43	1416	6.10
2627CA00142	11/03/1958	1627.96	-2939875.54	1416	7.62
2627CA00143	11/12/1958	1641.91	-2939861.14	1416	55.47
2627CA00144	02/10/1960	1627.96	-2939876.65	1416	54.56
2627CA00145	08/17/1973	1642.91	-2939861.14	1416	36.00
2627CA00146	07/07/1978	1627.96	-2939877.75	1416	30.00
2627CA00156	05/01/1962	23179.60	-2958723.45	1445	27.43
2627CA00157	05/15/1962	23184.58	-2958717.92	1445	21.34
2627CA00175	10/12/1956	6601.92	-2954461.47	1351	46.02
2627CA00178	06/28/1960	6611.87	-2954451.50	1351	18.29
2627CA00180	08/31/1965	6612.87	-2954451.50	1351	23.47
2627CA00181	10/15/1968	6601.92	-2954464.79	1351	5.18
2627CA00182	10/23/1968	6613.86	-2954451.50	1351	3.66
2627CA00183	10/16/1968	6601.92	-2954465.90	1351	5.18
2627CA00184	10/19/1968	6614.86	-2954451.50	1351	7.92
2627CA00185	05/02/1969	6601.91	-2954467.01	1351	5.49
2627CA00186	05/08/1969	6615.86	-2954451.50	1351	6.71
2627CA00187	09/25/1984	6601.91	-2954468.11	1351	7.00
2627CA00197	07/02/1991	10545.68	-2947355.30	1373	18.30
2627CA00199	07/02/1991	12694.92	-2945890.29	1410	30.73
2627CA00200	07/02/1991	8677.42	-2943397.30	1366	7.00
2627CA00201	07/02/1991	5287.59	-2946591.95	1383	4.64
2627CA00202	07/02/1991	2887.91	-2941565.41	1408	31.08
2627CA00203	07/02/1991	1366.60	-2933639.89	1446	1.80

BH ID	Date measured	Coordinated (WGS84, LO27)		Elevation	SWL
		X	Y	(50 m DTM)	(mbgl)
2627CA00204	07/02/1991	2146.05	-2933867.13	1434	12.00
2627CA00205	07/03/1991	10441.90	-2951268.61	1349	6.02
2627CA00207	07/03/1991	14796.48	-2941305.54	1420	11.50
2627CA00210	07/03/1991	21785.00	-2941783.13	1419	8.50
2627CA00211	07/03/1991	23103.50	-2941464.13	1402	18.10
2627CA00212	07/03/1991	22966.27	-2939114.97	1410	8.10
2627CA00213	07/03/1991	21108.64	-2936335.19	1455	10.00
2627CA00214	07/03/1991	22298.08	-2934330.68	1525	6.45
2627CA00216	07/03/1991	20947.93	-2935276.81	1494	14.60
2627CA00217	07/03/1991	18087.58	-2935210.40	1470	5.85
2627CA00219	07/03/1991	13325.47	-2933303.29	1406	12.80
2627CA00221	07/03/1991	11942.57	-2935772.68	1396	9.25
2627CA00222	07/03/1991	11017.72	-2938055.37	1394	5.84
2627CA00223	07/03/1991	13618.20	-2936424.73	1398	7.50
2627CA00224	07/03/1991	16161.99	-2936799.97	1439	20.75
2627CA00226	07/05/1991	17328.19	-2948353.26	1378	14.43
2627CA00227	07/05/1991	19349.05	-2949207.11	1364	22.75
2627CA00228	07/05/1991	20614.72	-2946575.42	1373	5.43
2627CA00230	07/05/1991	1748.85	-2937405.90	1424	30.50
2627CA00232	07/05/1991	6284.13	-2959142.57	1347	7.86
2627CA00233	07/05/1991	13367.51	-2957800.74	1326	5.24
2627CA00234	07/05/1991	17008.37	-2959656.57	1371	27.75
2627CA00236	07/05/1991	21882.82	-2953245.42	1364	12.70
2627CA00237	07/05/1991	21973.19	-2953360.80	1366	4.08
2627CA00238	07/05/1991	12308.93	-2954728.31	1348	11.13
2627CA00244	03/25/1991	9640.75	-2956303.78	1333	40.00
2627CA00245	04/04/1991	9643.73	-2956300.46	1333	24.00
2627CA00246	04/10/1991	9640.74	-2956304.89	1333	39.00
2627CA00248	06/29/1993	12279.71	-2942728.83	1406	66.00
2627CB00142	08/26/1950	26516.09	-2952630.45	1411	28.96
2627CB00143	03/29/1966	26509.11	-2952639.30	1411	3.96
2627CB00147	02/08/1984	28156.97	-2958639.36	1458	1.52
2627CB00148	02/06/1984	28157.97	-2958640.47	1458	1.52
2627CB00221	03/10/1950	26538.46	-2945249.05	1364	4.27
2627CB00222	04/22/1950	26539.45	-2945250.16	1363	6.40
2627CB00224	10/25/1950	26541.44	-2945252.38	1363	7.62
2627CB00226	04/29/1980	26543.43	-2945254.60	1363	1.00
2627CB00227	05/05/1980	26544.42	-2945255.71	1363	6.00
2627CB00229	06/25/1984	29889.35	-2941558.01	1384	15.00
2627CB00391	03/01/1984	19873.88	-2952926.34	1353	20.00

BH ID	Date measured	Coordinated (WGS84, LO27)		Elevation	SWL
		X	Y	(50 m DTM)	(mbgl)
2627CC00020	10/03/1957	20684.36	-2963702.94	1405	7.62
2627CC00021	10/15/1957	20688.34	-2963699.62	1406	1.83
2627CC00023	11/18/1957	20689.34	-2963699.62	1406	22.86
2627CC00024	11/25/1957	20684.36	-2963705.16	1406	10.67
2627CC00025	12/20/1958	20690.33	-2963699.63	1406	5.49
2627CC00028	04/28/1959	20684.35	-2963707.37	1406	24.38
2627CC00029	05/19/1959	20692.32	-2963699.63	1406	19.81
2627CC00030	05/08/1959	20684.35	-2963708.48	1406	33.53
2627CC00032	10/13/1959	20684.35	-2963709.59	1406	9.75
2627CC00033	11/26/1959	20694.31	-2963699.63	1406	24.38
2627CC00035	12/24/1959	20695.31	-2963699.63	1406	9.14
2627CC00036	01/12/1960	20684.35	-2963711.80	1406	3.05
2627CC00038	11/27/1962	20684.35	-2963712.91	1406	19.81
2627CC00039	06/25/1979	20697.29	-2963699.64	1406	5.00
2627CC00041	07/12/1979	20698.29	-2963699.64	1406	7.00
2627CC00043	10/01/1987	20699.28	-2963699.64	1406	24.00
2627CC00056	04/04/1969	4935.77	-2972920.02	1327	11.10
2627CC00057	05/05/1969	4937.76	-2972917.80	1327	9.68
2627CC00059	12/12/1979	4938.75	-2972917.80	1327	20.00
2627CC00063	05/29/1950	8254.83	-2965225.52	1331	3.66
2627CC00064	07/01/1950	8252.64	-2965534.65	1332	3.66
2627CC00065	06/12/1950	8255.83	-2965224.41	1331	3.66
2627CC00066	08/01/1958	8252.64	-2965535.76	1332	5.49
2627CC00067	08/09/1958	8256.62	-2965532.44	1332	4.57
2627CC00077	09/06/1984	20123.61	-2969244.31	1395	20.00
2627CC00090	08/17/1950	14877.25	-2969237.03	1350	1.52
2627CC00091	08/16/1958	14883.22	-2969231.50	1350	20.42
2627CC00092	10/22/1984	14877.25	-2969238.14	1350	18.00
2627CC00093	10/24/1984	14884.22	-2969231.50	1350	16.50
2627CC00104	01/12/1950	1628.46	-2974762.89	1303	6.10
2627CC00105	02/21/1950	1623.49	-2974769.54	1303	22.56
2627CC00110	03/21/1950	1631.44	-2974762.89	1303	10.36
2627CC00111	12/21/1965	1623.49	-2974772.87	1303	33.53
2627CC00117	08/31/1968	18195.60	-2965546.16	1388	23.17
2627CC00118	02/17/1969	18198.58	-2965542.84	1388	23.70
2627CC00122	03/30/1971	11841.44	-2968305.31	1357	34.75
2627CC00123	05/13/1971	11842.43	-2968305.31	1357	35.36
2627CC00125	11/07/1964	23447.92	-2963705.55	1405	12.19
2627CC00133	10/30/1950	9903.95	-2978460.83	1324	21.34
2627CC00134	08/23/1958	9899.97	-2978465.26	1324	12.80

BH ID	Date measured	Coordinated (WGS84, LO27)		Elevation	SWL
		X	Y	(50 m DTM)	(mbgl)
2627CC00136	07/03/1991	4771.86	-2962265.36	1336	15.53
2627CC00137	07/03/1991	14119.87	-2962960.41	1337	23.16
2627CC00138	07/03/1991	19207.06	-2967990.83	1381	13.74
2627CC00139	07/03/1991	18910.31	-2968329.43	1379	14.53
2627CC00140	07/03/1991	18953.89	-2962470.34	1381	16.96
2627CC00141	07/03/1991	21960.50	-2964121.70	1387	8.24
2627CC00142	07/03/1991	13740.17	-2971917.14	1363	10.06
2627CC00143	07/03/1991	9895.94	-2968423.30	1345	11.00
2627CC00144	07/03/1991	7836.25	-2969995.22	1321	8.67
2627CC00145	07/03/1991	5345.04	-2970908.03	1319	5.82
2627CC00146	07/03/1991	6503.50	-2975516.81	1357	33.23
2627CC00147	07/04/1991	14141.88	-2974378.49	1350	12.21
2627CC00149	07/03/1991	19217.90	-2970662.27	1391	9.96
2627CC00150	07/04/1991	20616.82	-2975209.58	1395	9.96
2627CC00165	07/04/1991	9562.32	-2978385.22	1321	11.19
2627CC00166	07/04/1991	4630.95	-2974929.84	1341	26.51
2627CC00167	07/09/1991	6531.41	-2963817.34	1321	7.45
2627CD00064	09/18/1991	27071.62	-2963276.23	1442	12.75
2627CD00065	09/18/1991	25254.83	-2970169.87	1472	29.24
2627CD00066	09/18/1991	28964.41	-2967056.55	1482	1.26
2627CD00286	06/12/1961	25643.20	-2970787.82	1485	12.19
2627CD00288	09/17/1961	25644.20	-2970787.83	1485	18.59
2627CD00289	11/11/1961	25642.20	-2970791.15	1485	22.86
2627CD00290	10/09/1961	25645.19	-2970787.83	1485	13.72
2627CD00291	12/19/1961	25642.20	-2970792.25	1485	12.19
2627CD00292	11/20/1961	25646.18	-2970787.83	1485	13.72
2627CD00293	12/07/1961	25642.20	-2970793.36	1485	10.67
2627CD00294	01/10/1962	25647.18	-2970787.83	1485	6.10
2627CD00301	04/23/1960	28963.32	-2967101.97	1483	16.76
2627CD00304	03/16/1966	28965.30	-2967101.98	1483	12.50
2627CD00305	11/17/1967	28963.31	-2967104.19	1483	11.58
2627CD00306	12/13/1967	28966.30	-2967101.98	1483	7.92
2627CD00307	01/10/1968	28963.31	-2967105.30	1483	5.49
2627CD00308	06/01/1983	28967.29	-2967101.98	1483	23.00
2627CD00310	08/10/1984	28968.29	-2967101.98	1483	5.00
2627CD00311	08/13/1984	28963.30	-2967107.51	1483	5.00

APPENDIX B

GROUNDWATER HYDROCHEMISTRY RESULTS

Groundwater

Borehole: ZQMVFD1

Parameter (mg/l)	Unit	DWA SAWQTV drinking water	SANS 241-1: 2011	06/04/2000	06/09/2000	10/04/2001	08/05/2002	17/10/2002	01/06/1995	14/11/1995	16/05/1996	25/11/1996	20/06/1997	05/11/1997	05/10/1998	29/09/1999
Calcium, Ca	mg/L	<32	NS	1.873	1.419	1.914	2.582	1.787	1.2	1.7	1.5	7.1	1.8	3.2	1.6	1.9
Chloride, Cl	mg/L	<100	<300	5	5	5	5	5	3.3	3.6	3.6	3.4	3.3	3.3	3.3	3.7
Conductivity mS/m @ 25 °C	mS/m	<70	<170	2.54	2.49	2.86	2.74	3.01	2.6	3	3	6.1	3.2	2.7	2.5	1
Fluoride	mg/L	1	1.5	0.107	0.05	0.05	0.168	0.117	0.13	0.05	0.17	0.05	0.1	0.11	0.37	0.11
Total hardness as $CaCO_3$	mg/L	NS	NS	9.187	5.603	9.137	10.957	6.522	7.527	6.304	5.805	21.848	6.554	20.346	8.526	9.275
Potassium, K	mg/L	<50	NS	0.504	0.641	0.977	0.934	0.743	2.15	2.43	1.22	0.74	0.59	0.65	0.63	0.49
Magnesium, Mg (mg/l)	mg/L	<30	NS	1.095	0.5	1.058	1.095	0.5	1.1	0.5	0.5	1	0.5	3	1.1	1.1
Sodium, Na	mg/L	<100	<200	2.231	1	1	1	1	2.1	2.1	2.7	1	2.1	1	2.2	1
Nitrate, NO_3	mg/L	<26.6	<48.7	0.41	0.355	0.526	0.825	0.672	0.568	0.511	0.781	0.661	0.573	0.615	0.606	0.54
pH at 22 °C	pH units	6-9	5-9.7	6.424	6.431	6.604	7.348	6.517	6.62	6.26	5.95	6.96	5.83	5.76	6.2	5.71
Silicon, Si	mg/L	NS	NS	4.188	4.302	4.698	4.286	4.461	4.66	4.44	4.27	4.52	4.64	4.32	6.06	4.22
Sulphate, SO_4	mg/L	<200	<500	5.35	5.143	6.887	2	2	2	2	2	2	2	4.2	2	2
Total alkalinity as $CaCO_3$	mg/L	NS	NS	9.11	7.996	2	9.506	9.454	12.8	7	6	24.6	13	10.5	2	6.4
Bicarbonate as $CaCO_3$	mg/L	NS	NS	11.11	9.75	2.44	11.56	11.53	15.61	8.54	7.32	29.98	15.86	12.81	2.44	7.81

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Borehole: ZQMVFD2

Parameter (mg/l)	Unit	DWA SAWQTV drinking water	SANS 241-1: 2011	08/05/2003
Calcium, Ca	mg/L	<32	NS	10.028
Chloride, Cl	mg/L	<100	<300	5
Conductivity mS/m @ 25 °C	mS/m	<70	<170	15
Fluoride	mg/L	1	1.5	0.247
Total hardness as $CaCO_3$	mg/L	NS	NS	45.464
Potassium, K	mg/L	<50	NS	0.15
Magnesium, Mg (mg/l)	mg/L	<30	NS	4.959
Sodium, Na	mg/L	<100	<200	6.239
Nitrate, NO_3	mg/L	<26.6	<48.7	2.761
pH at 22 °C	pH units	6-9	5-9.7	7.35
Silicon, Si	mg/L	NS	NS	22.369
Sulphate, SO_4	mg/L	<200	<500	5.779
Total alkalinity as $CaCO_3$	mg/L	NS	NS	43.771
Bicarbonate as $CaCO_3$	mg/L	NS	NS	53.27

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Borehole: ZQMVFD3

Parameter (mg/l)	Unit	DWA SAWQTV drinking water	SANS 241-1: 2011	22/10/2003	19/05/2004	20/10/2004	11/05/2005	14/09/2005	05/03/2006	13/09/2006	19/09/2007	23/04/2008	04/09/2008	16/09/2009	16/04/2009	30/09/2010
Calcium, Ca	mg/L	<32	NS	8.932	8.6	8.069	8.768	9.104	8.317	10.555	14.25	9.529	7.312	8.262	8.28	10.572
Chloride, Cl	mg/L	<100	<300	5	2.5	5.376	4.709	6.505	4.385	2	2	4.347	2.451	3.095	2.51	4.647
Conductivity mS/m @ 25 °C	mS/m	<70	<170	12.94	12.13	13.1	11.67	11.65	14.1	14.2	14.7	10.93	11.01	12.68	12.23	15.2
Fluoride, F	mg/L	1	1.5	**0.16**	**0.1**	**0.1**	**0.16**	**0.108**	**0.169**	**0.261**	0.05	**0.13**	-	-	**0.398**	0.025
Total hardness as $CaCO_3$	mg/L	NS	NS	43.361	41.54	38.962	40.868	42.44	40.743	47.995	55.744	41.187	36.969	42.318	34.308	55.195
Potassium, K	mg/L	<50	NS	0.313	0.347	0.409	0.367	0.15	0.358	0.407	0.404	0.331	**1.359**	**1.24**	**1.46**	**1.75**
Magnesium, Mg (mg/l)	mg/L	<30	NS	5.113	4.872	4.568	4.607	4.785	4.85	5.254	4.895	4.223	4.543	5.266	3.31	6.992
Sodium, Na	mg/L	<100	<200	7.071	7.067	6.087	6.608	6.093	6.566	7.179	7.866	5.72	2.759	5.8	5.09	6.11
Nitrate, NO_3	mg/L	<26.6	<48.7	**2.45**	**2.006**	**1.919**	**1.718**	0.632	**1.435**	**1.521**	**1.575**	**1.523**	**1.612**	**1.437**	**1.35**	**2.23**
pH at 22 °C	pH units	6-9	5-9.7	6.868	7.477	7.209	7.258	7.507	7.694	7.23	7.714	7.407	7.65	8.144	8.12	7.967
Silicon, Si	mg/L	NS	NS	23.01	24.04	21.815	22.006	22.28	21.956	23.322	22.176	22.362	21.485	23.216	21.8	21.622
Sulphate, SO_4	mg/L	<200	<500	4.97	3	3	2	4.027	2	2	2	2	0.602	3	3	6.263
Total alkalinity as $CaCO_3$	mg/L	NS	NS	42.102	44.684	35.418	45.136	42.024	48.606	49.829	54.269	43.992	37.2	40.056	43.8	59.742
Bicarbonate as $CaCO_3$	mg/L	NS	NS	51.32	54.34	43.13	54.96	51.10	59.00	60.68	65.86	53.53	45.17	48.15	52.70	72.20

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Borehole: ZQMVFD3 (continued)

Parameter (mg/l)	Unit	DWA SAWQTV drinking water	SANS 241-1: 2011	07/04/2011	14/09/2011	18/04/2012	19/09/2012	22/05/2013
Calcium, Ca	mg/L	<32	NS	12.288	10.606	11.986	11.269	8.889
Chloride, Cl	mg/L	<100	<300	2.592	4.005	3.458	5.387	8.823
Conductivity mS/m @ 25 °C	mS/m	<70	<170	14.49	14.45	17.91	14.59	14.74
Fluoride	mg/L	1	1.5	**0.31**	**0.112**	**0.105**	**0.108**	**0.108**
Total hardness as $CaCO_3$	mg/L	NS	NS	58.344	50.12	54.727	55.766	43.921
Potassium, K	mg/L	<50	NS	**1.158**	**2.243**	**2.223**	**2.053**	**10.644**
Magnesium, Mg (mg/l)	mg/L	<30	NS	6.716	5.739	6.021	6.708	5.275
Sodium, Na	mg/L	<100	<200	8.942	9.041	6.459	6.132	8.06
Nitrate, NO_3	mg/L	<26.6	<48.7	0.723	0.964	**1.789**	**2.752**	**2.574**
pH at 22 °C	pH units	6-9	5-9.7	7.475	7.299	7.559	6.813	8.068
Silicon, Si	mg/L	NS	NS	21.763	21.834	22.187	25.081	57.245
Sulphate, SO_4	mg/L	<200	<500	4.718	7.489	8.516	5.122	3.411
Total alkalinity as $CaCO_3$	mg/L	NS	NS	62.425	60.221	57.099	52.66	40.602
Bicarbonate as $CaCO_3$	mg/L	NS	NS	75.93	73.32	69.40	64.20	48.93

Exceed the DWA SAWQTV standards

Exceed the SANS standards

APPENDIX C

FLOW GAUGE HYDROCHEMISTRY RESULTS

C2H001Q01

Parameter (mg/l)	*Unit*	DWA SAWQTV Drinking Water	SANS 241-1: 2011	09/02/1999	16/02/1999	23/02/1999	02/03/1999	09/03/1999	17/03/1999	24/03/1999	31/03/1999	06/04/1999	19/04/1999	03/05/1999	11/05/1999	18/05/1999	25/05/1999
Calcium, Ca	mg/L	<32	NS	69.8	69.8	74.2	58.7	70.1	73.5	75.6	74.1	75	65.4	59.9	-	57.5	56.9
Chloride, Cl	mg/L	<100	<300	21.5	22.4	24.1	24.2	23.4	21.8	23.3	21.9	19.8	19.8	21.5	24.3	23.7	23.9
Conductivity mS/m @ 25 °C	mS/m	<70	<170	76.4	73.2	77.4	66.7	73.3	75.5	74.9	74.4	73.6	70.5	68	71	67.9	68.4
Fluoride, F	mg/L	1	1.5	0.11	0.18	0.16	0.2	0.16	0.21	0.17	0.15	0.15	0.16	0.15	0.17	0.16	0.15
Potassium, K	mg/L	<50	NS	1.61	1.72	1.72	1.59	2.04	1.63	1.67	1.39	1.54	1.59	1.63	2.06	1.97	1.97
Magnesium, Mg (mg/l)	mg/L	<30	NS	51.3	49.7	50.9	43.1	49.7	50.3	49.6	49.8	47.8	46.6	42.3	42.5	44.7	43.6
Sodium, Na	mg/L	<100	<200	18.9	20	18.5	20.5	18.4	17.7	17.5	17.3	16.9	18.2	20.8	23.2	22.9	21.4
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.518	0.555	0.615	0.243	0.503	0.632	0.777	0.761	0.762	0.654	0.382	0.253	0.208	0.369
pH at 22 °C	pH units	6-9	5-9.7	8.12	8.42	8.47	8.32	8.25	8.28	8.51	8.39	8.4	8.24	8.33	8.09	8.26	8.22
Sulphate, SO_4	mg/L	<200	<500	82.9	89.4	88.3	92.9	89	78.9	80.5	86.5	87.4	81.3	96.4	102.4	100.8	102.7
Ammonium, NH_4	mg/L	<1.0	<1.5	0.068	0.02	0.049	0.02	0.02	0.048	0.05	0.043	0.02	0.02	0.02	0.052	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	85.16	85.16	90.52	71.61	85.52	89.67	92.23	90.40	91.50	79.79	73.08	-	70.15	69.42

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	*Unit*	DWA SAWQTV Drinking Water	SANS 241-1: 2011	01/06/1999	08/06/1999	15/06/1999	22/06/1999	29/06/1999	06/07/1999	13/07/1999	20/07/1999	27/07/1999	03/08/1999	17/08/1999	24/08/1999	07/09/1999	13/09/1999
Calcium, Ca	mg/L	<32	NS	56.8	59.1	60.6	61.7	59.8	56.8	55.4	61.5	64.3	62.3	61.4	60.3	61.1	64.3
Chloride, Cl	mg/L	<100	<300	25	25.5	23.9	25	19.9	23.2	23.7	23.7	25.5	27.8	35.4	20.3	25.9	25.7
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69.1	70.4	70.2	69.9	70.7	72	71.3	71.8	73.5	76.9	70.9	68.4	75.8	76
Fluoride, F	mg/L	1	1.5	0.18	0.16	0.13	0.15	0.17	0.17	0.14	0.16	0.15	0.15	0.15	0.15	0.15	0.15
Potassium, K	mg/L	<50	NS	2.22	2.35	2.29	1.92	1.78	1.95	1.82	1.87	1.93	3.28	2.3	1.67	2.16	2.09
Magnesium, Mg (mg/l)	mg/L	<30	NS	39.1	41.7	43.8	-	42.2	43.5	45	44.8	45.8	48.6	46.2	45.9	46.8	50.8
Sodium, Na	mg/L	<100	<200	23.8	24.6	23.4	22.9	24.2	24	21.6	23.5	24.1	25.7	24.8	23.9	24.4	23.4
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.194	0.276	0.297	0.298	0.294	0.324	0.288	0.327	0.348	0.432	0.165	0.182	0.321	0.378
pH at 22 °C	pH units	6-9	5-9.7	8.29	8.33	8.21	8.21	8.34	8.25	8.63	8.49	8.28	8.33	8.75	8.97	8.25	8.16
Sulphate, SO_4	mg/L	<200	<500	109.5	108.9	106.9	112.6	111.3	105.9	101.6	122.2	114.3	112.9	107.9	112.9	108.8	108.5
Ammonium, NH_4	mg/L	<1.0	<1.5	0.049	0.057	0.02	0.02	0.02	0.094	0.02	0.02	0.054	0.086	0.04	0.02	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	69.30	72.10	73.93	75.27	72.96	69.30	67.59	75.03	78.45	76.01	74.91	73.57	74.54	78.45

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	20/09/1999	28/09/1999	04/10/1999	11/10/1999	18/10/1999	25/10/1999	02/11/1999	08/11/1999	15/11/1999	22/11/1999	29/11/1999	06/12/1999	13/12/1999	20/12/1999
Calcium, Ca	mg/L	<32	NS	**62.6**	**70.056**	**68.583**	**60.701**	**69.824**	**79.098**	**69.474**	**71.459**	**69.374**	**68.806**	**64.398**	**72.683**	**73.113**	**71.149**
Chloride, Cl	mg/L	<100	<300	22.4	23.713	23.382	20.732	19.974	22.051	25.576	21.458	21.521	20.008	23.232	21.318	21.29	21.024
Conductivity mS/m @ 25 °C	mS/m	<70	<170	**76.6**	**75.3**	**76.1**	**74.5**	**74.9**	**77**	**77.3**	**75.1**	**72.3**	**74.8**	**73.7**	**72.5**	**76.8**	**75.7**
Fluoride, F	mg/L	1	1.5	0.13	0.159	0.147	0.186	0.154	0.146	0.184	0.149	0.168	0.219	0.172	0.145	0.169	0.157
Potassium, K	mg/L	<50	NS	1.56	1.731	1.46	1.479	1.164	1.495	2.266	1.275	1.38	1.526	1.648	1.531	1.49	1.946
Magnesium, Mg (mg/l)	mg/L	<30	NS	**48.9**	**53.356**	**50.389**	**49.813**	**48.596**	**49.903**	**49.017**	**46.248**	**49.054**	**44.523**	**46.711**	**48.132**	**48.925**	**48.286**
Sodium, Na	mg/L	<100	<200	18.8	22.257	21.188	18.532	17.759	17.104	20.434	18.98	18.086	17.73	18.324	16.912	17.184	21.673
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.444	0.414	0.354	0.527	0.441	0.438	0.386	0.476	0.396	0.174	0.408	0.49	0.462	0.473
pH at 22 °C	pH units	6-9	5-9.7	8.2	8.108	8.176	8.253	8.244	8.198	8.22	8.155	8.993	8.324	8.854	8.684	8.092	8.136
Sulphate, SO_4	mg/L	<200	<500	84.3	98.151	90.707	79.746	74.174	85.937	96.161	79.955	85.634	84.617	95.331	76.449	77.227	75.491
Ammonium, NH_4	mg/L	<1.0	<1.5	0.046	0.053	0.02	0.047	0.02	0.02	0.02	0.07	0.02	0.02	0.07	0.052	0.082	0.068
Bicarbonate as $CaCO_3$	mg/L	NS	NS	76.37	85.47	83.67	74.06	85.19	96.50	84.76	87.18	84.64	83.94	78.57	88.67	89.20	86.80

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	28/12/1999	18/01/2000	26/01/2000	01/02/2000	22/02/2000	29/02/2000	07/03/2000	11/04/2000	18/04/2000	03/05/2000	10/05/2000	16/05/2000	23/05/2000	30/05/2000
Calcium, Ca	mg/L	<32	NS	**75.564**	**46.219**	**47.753**	**50.381**	**33.491**	**38.855**	**38.839**	**47.411**	**50.677**	**51.645**	**54.111**	**54.461**	**51.935**	**56.929**
Chloride, Cl	mg/L	<100	<300	23.096	25.756	25.294	26.71	11.232	13.777	11.548	15.458	15.561	16.783	17.679	17.941	18.517	18.217
Conductivity mS/m @ 25 °C	mS/m	<70	<170	**77.3**	64.8	68	67	40.9	45.6	45.3	54.9	55.4	59.8	60.5	60.7	61.2	63.1
Fluoride, F	mg/L	1	1.5	0.197	0.05	0.149	0.176	0.151	0.158	0.179	0.142	0.211	0.185	0.148	0.162	0.15	0.174
Potassium, K	mg/L	<50	NS	1.497	2.084	1.958	1.923	3.215	2.957	2.888	2.546	2.755	2.856	2.172	2.698	2.24	2.53
Magnesium, Mg (mg/l)	mg/L	<30	NS	**51.201**	**43.089**	**43.242**	**43.829**	21.618	24.076	24.388	29.998	**32.051**	**36.054**	**35.425**	**34.08**	**36.062**	**37.438**
Sodium, Na	mg/L	<100	<200	16.623	26.233	22.851	24.642	11.937	12.213	13.563	16.042	15.555	16.823	18.17	20.098	18.249	18.754
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.443	0.086	0.196	0.189	0.044	0.099	0.041	0.159	0.225	0.223	0.194	0.355	0.247	0.263
pH at 22 °C	pH units	6-9	5-9.7	8.347	8.356	8.388	8.584	8.282	8.56	7.869	8.335	8.384	8.378	8.375	8.346	8.259	8.307
Sulphate, SO_4	mg/L	<200	<500	79.596	112.417	106.255	111.933	40.56	44.789	42.162	59.918	60.647	70.597	67.67	71.068	71.884	75.518
Ammonium, NH_4	mg/L	<1.0	<1.5	0.05	0.02	0.055	0.075	0.02	0.02	0.02	0.053	0.102	0.02	0.02	0.02	0.057	0.051
Bicarbonate as $CaCO_3$	mg/L	NS	NS	92.19	56.39	58.26	61.46	40.86	47.40	47.38	57.84	61.83	63.01	66.02	66.44	63.36	69.45

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	06/06/2000	13/06/2000	20/06/2000	27/06/2000	04/07/2000	11/07/2000	25/07/2000	01/08/2000	15/08/2000	22/08/2000	29/08/2000	05/09/2000	12/09/2000	19/09/2000
Calcium, Ca	mg/L	<32	NS	58.224	57.771	60.568	59.165	58.88	62.766	60.972	61.501	64.051	63.821	65.648	65.668	62.105	69.591
Chloride, Cl	mg/L	<100	<300	19.833	18.636	18.488	20.934	20.118	21.766	20.955	21.613	21.005	21.228	22.257	21.588	21.54	22.649
Conductivity mS/m @ 25 °C	mS/m	<70	<170	64.1	65	65.4	66.2	66.9	67.9	68.9	69.2	70.5	70	70.4	69.9	71.7	74.4
Fluoride, F	mg/L	1	1.5	0.203	0.18	0.167	0.18	0.158	0.158	0.15	0.167	0.14	0.145	0.133	0.22	1.925	0.153
Potassium, K	mg/L	<50	NS	2.372	2.252	2.291	2.492	2.232	2.166	2.487	2.753	2.588	2.767	2.461	2.414	2.508	2.717
Magnesium, Mg (mg/l)	mg/L	<30	NS	35.459	37.667	39.647	37.632	38.222	37.01	37.897	42.581	40.671	44.666	45.673	42.693	43.114	44.546
Sodium, Na	mg/L	<100	<200	19.238	19.063	21.233	21.757	18.64	21.482	21.513	22.707	23.59	20.487	22.092	23.466	23.509	20.863
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.291	0.295	0.29	0.331	0.341	0.427	0.321	0.351	0.335	0.349	0.397	0.389	0.525	0.462
pH at 22 °C	pH units	6-9	5-9.7	8.401	8.315	8.363	8.307	8.328	8.304	8.274	8.455	8.397	8.409	8.32	8.501	8.315	8.264
Sulphate, SO_4	mg/L	<200	<500	80.094	80.14	78.983	82.028	83.986	90.603	90.714	96.799	98.223	94.026	97.288	96.442	100.225	98.499
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.02	0.02	0.02	0.02	0.276	0.02	0.02	0.047	0.136	0.052	0.069	0.096
Bicarbonate as $CaCO_3$	mg/L	NS	NS	71.03	70.48	73.89	72.18	71.83	76.57	74.39	75.03	78.14	77.86	80.09	80.11	75.77	84.90

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	27/09/2000	12/10/2000	16/10/2000	24/10/2000	31/10/2000	07/11/2000	14/11/2000	21/11/2000	29/11/2000	06/12/2000	13/12/2000	19/12/2000	28/12/2000	03/01/2001
Calcium, Ca	mg/L	<32	NS	63.669	60.615	59.359	60.213	57.425	60.116	59.498	60.231	57.215	58.037	55.721	53.089	53.154	52.888
Chloride, Cl	mg/L	<100	<300	24.727	22.608	22.484	23.58	25.404	22.794	23.798	24.078	22.559	21.994	23.997	22.677	20.46	17.907
Conductivity mS/m @ 25 °C	mS/m	<70	<170	70.3	69.4	69.5	70.4	69.9	67.8	67.1	68.8	64.6	66.8	67.1	66.1	63.8	65.4
Fluoride, F	mg/L	1	1.5	0.154	0.164	0.14	0.145	0.15	0.159	0.141	0.142	0.163	0.151	0.138	0.14	0.135	0.135
Potassium, K	mg/L	<50	NS	2.542	2.415	2.1	2.677	2.1	1.976	1.833	2.072	2.284	2.187	2.195	1.744	1.875	1.786
Magnesium, Mg (mg/l)	mg/L	<30	NS	41.877	40.172	43.074	43.954	44.956	42.957	43.565	43.429	40.047	35.922	43.031	42.166	41.071	40.432
Sodium, Na	mg/L	<100	<200	23.688	21.233	21.876	26.76	23.996	23.85	23.267	24.51	23.477	24.048	24.656	24.09	20.926	20.641
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.29	0.394	0.352	0.331	0.283	0.223	0.285	0.326	0.234	0.26	0.214	0.176	0.196	0.245
pH at 22 °C	pH units	6-9	5-9.7	8.219	8.302	8.339	8.369	8.207	8.138	8.545	8.18	8.294	8.192	8.345	8.354	8.323	8.056
Sulphate, SO_4	mg/L	<200	<500	99.874	97.265	105.378	101.866	103.93	99.056	100.076	105.7	107.799	105.519	108.336	104.624	82.056	83.32
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.061	0.02	0.066	0.054	0.02	0.02	0.02	0.02	0.05	0.053	0.02	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	77.68	73.95	72.42	73.46	70.06	73.34	72.59	73.48	69.80	70.81	67.98	64.77	64.85	64.52

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	09/01/2001	16/01/2001	23/01/2001	30/01/2001	06/02/2001	13/02/2001	20/02/2001	27/02/2001	06/03/2001	13/03/2001	20/03/2001	27/03/2001	03/04/2001	10/04/2001
Calcium, Ca	mg/L	<32	NS	52.521	67.053	70.771	69.807	59.93	64.656	72.36	55.167	54.815	49.386	48.411	51.747	53.836	54.914
Chloride, Cl	mg/L	<100	<300	20.747	22.285	26.83	21.084	22.559	22.245	23.748	22.677	22.718	23.685	21.167	23.88	22.325	20.85
Conductivity mS/m @ 25 °C	mS/m	<70	<170	66.1	74.1	77.9	73.6	71.6	72.4	75.7	67	67.8	66.1	65.9	67.6	65.8	66.1
Fluoride, F	mg/L	1	1.5	0.152	0.172	0.16	0.168	0.17	0.157	0.176	0.163	0.169	0.14	0.152	0.178	0.179	0.146
Potassium, K	mg/L	<50	NS	2.003	2.146	1.778	1.719	3.589	1.824	2.371	2.275	2.117	1.659	2.177	1.953	2.164	2.198
Magnesium, Mg (mg/l)	mg/L	<30	NS	41.709	48.456	50.658	51.311	45.162	46.845	49.845	42.713	41.739	42.751	42.705	42.951	37.979	41.028
Sodium, Na	mg/L	<100	<200	19.928	20.324	21.996	18.217	19.953	19.486	19.436	24.137	22.366	21.014	20.028	22.436	21.194	22.253
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.332	0.63	0.61	0.618	0.423	0.463	0.473	0.127	0.259	0.23	0.22	0.148	0.149	0.182
pH at 22 °C	pH units	6-9	5-9.7	8.265	8.176	8.274	8.28	8.263	8.264	8.213	8.238	8.275	8.233	8.184	8.271	8.4	8.265
Sulphate, SO_4	mg/L	<200	<500	83.281	87.31	78.57	81.927	89.125	98.88	95.816	107.432	100.46	89.032	92.995	98.284	89.872	99.863
Ammonium, NH_4	mg/L	<1.0	<1.5	0.047	0.047	0.053	0.052	0.02	0.059	0.02	0.02	0.02	0.056	0.02	0.054	0.02	0.045
Bicarbonate as $CaCO_3$	mg/L	NS	NS	64.08	81.80	86.34	85.16	73.11	78.88	88.28	67.30	66.87	60.25	59.06	63.13	65.68	67.00

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	17/04/2001	24/04/2001	08/05/2001	15/05/2001	22/05/2001	29/05/2001	05/06/2001	12/06/2001	19/06/2001	08/07/2001	10/07/2001	17/07/2001	24/07/2001	31/07/2001
Calcium, Ca	mg/L	<32	NS	52.839	53.278	56.807	58.246	57.341	63.228	55.965	62.453	60.987	59.124	61.9	64.895	63.437	63.847
Chloride, Cl	mg/L	<100	<300	25.498	23.482	20.106	23.035	22.288	21.782	23.851	19.545	19.93	23.914	23.005	25.816	22.054	21.185
Conductivity mS/m @ 25 °C	mS/m	<70	<170	70.2	67.1	67.7	67.1	68.4	68.1	62	67.8	68	69.4	70.2	70.1	70.5	70.1
Fluoride, F	mg/L	1	1.5	0.156	0.163	0.147	0.155	0.151	0.154	0.145	0.137	0.146	0.151	0.137	0.15	0.144	0.138
Potassium, K	mg/L	<50	NS	2.631	2.246	2.199	2.355	2.029	2.631	1.869	1.93	1.961	2.247	2.219	2.583	2.312	2.35
Magnesium, Mg (mg/l)	mg/L	<30	NS	42.999	41.661	37.342	41.35	45.316	48.85	37.2	42.216	44.14	43.71	42.977	43.087	44.184	44.911
Sodium, Na	mg/L	<100	<200	21.784	21.237	22.114	20.794	22.463	21.854	19.324	21.863	23.729	20.674	20.064	22.187	21.783	20.6
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.237	0.229	0.261	0.127	0.298	0.294	0.547	0.351	0.368	0.412	0.387	0.378	0.435	0.381
pH at 22 °C	pH units	6-9	5-9.7	8.161	8.259	8.187	8.233	8.217	8.199	8.199	8.21	8.56	8.39	8.451	8.283	8.313	8.495
Sulphate, SO_4	mg/L	<200	<500	90.944	93.09	98.239	94.728	97.444	106.322	91.681	103.967	105.939	103.168	101.579	102.424	99.518	101.465
Ammonium, NH_4	mg/L	<1.0	<1.5	0.079	0.02	0.054	0.02	0.047	0.046	0.049	0.054	0.046	0.075	0.02	0.06	0.095	0.055
Bicarbonate as $CaCO_3$	mg/L	NS	NS	64.46	65.00	69.30	71.06	69.96	77.14	68.28	76.19	74.40	72.13	75.52	79.17	77.39	77.89

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	07/08/2001	14/08/2001	21/08/2001	29/08/2001	04/09/2001	11/09/2001	19/09/2001	26/09/2001	02/10/2001	09/10/2001	06/11/2001	14/11/2001	21/11/2001	28/11/2001
Calcium, Ca	mg/L	<32	NS	**65.999**	**62.88**	**61.989**	**61.694**	**57.431**	**64.93**	**62.908**	**62.702**	**60.356**	**57.874**	**58.354**	**58.199**	**56.053**	**51.453**
Chloride, Cl	mg/L	<100	<300	21.443	23.14	21.034	24.371	22.262	21.631	34.433	21.922	19.551	22.424	22.316	21.647	20.274	20.674
Conductivity mS/m @ 25 °C	mS/m	<70	<170	**70.6**	**70.7**	**70.7**	**71**	**70.3**	**70.7**	**71.1**	**70.3**	**70.4**	**71.2**	67.4	67.7	66.1	61.7
Fluoride, F	mg/L	1	1.5	0.145	0.167	0.157	0.125	0.136	0.134	0.17	0.133	0.14	0.163	0.136	0.14	0.153	0.159
Potassium, K	mg/L	<50	NS	2.116	2.137	1.933	2.475	3.545	1.961	2.422	2.011	2.322	2.228	2.531	2.041	2.32	2.91
Magnesium, Mg (mg/l)	mg/L	<30	NS	**42.052**	**43.93**	**42.973**	**44.389**	**37.619**	**44.434**	**43.873**	**43.809**	**44.393**	**45.014**	**43.876**	**41.988**	**43.066**	**37.81**
Sodium, Na	mg/L	<100	<200	23.933	22.412	21.748	22.132	24.481	21.787	28.248	22.271	22.115	23.034	22.476	20.07	19.122	18.841
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.386	0.509	0.437	0.498	0.462	0.446	0.493	0.42	0.383	0.415	0.349	0.338	0.235	0.181
pH at 22 °C	pH units	6-9	5-9.7	8.308	8.261	8.274	8.322	8.292	8.258	8.296	8.294	8.232	8.318	8.34	8.3	8.429	8.224
Sulphate, SO_4	mg/L	<200	<500	99.832	95.235	111.3	107.954	101.182	96.784	100.111	105.062	93.99	96.799	98.154	104.107	94.666	85.88
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.059	0.058	0.076	0.083	0.066	0.045	0.051	0.102	0.02	0.068	0.02	0.055	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	80.52	76.71	75.63	75.27	70.07	79.21	76.75	76.50	73.63	70.61	71.19	71.00	68.38	62.77

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	12/12/2001	20/12/2001	04/01/2002	09/01/2002	15/01/2002	23/01/2002	29/01/2002	06/02/2002	13/02/2002	20/02/2002	27/02/2002	06/03/2002	13/03/2002	20/03/2002
Calcium, Ca	mg/L	<32	NS	**49.445**	**52.356**	**56.046**	**56.308**	**55.797**	**59.768**	30.236	**48.054**	**52.394**	**51.446**	**48.332**	**43.383**	**51.793**	**53.453**
Chloride, Cl	mg/L	<100	<300	17.607	17.13	16.929	17.537	19.837	20.645	28.68	19.754	21.001	22.307	21.895	21.444	18.681	21.024
Conductivity mS/m @ 25 °C	mS/m	<70	<170	59.7	58.3	62.1	64.6	62.6	62.6	38.9	59.9	61.7	59.9	61.1	62.4	63.4	62.1
Fluoride, F	mg/L	1	1.5	0.18	0.172	0.153	0.161	0.172	0.172	0.279	0.15	0.16	0.172	0.231	0.161	0.214	0.165
Potassium, K	mg/L	<50	NS	1.992	2.47	2.314	2.399	3.335	2.097	6.079	2.616	2.272	2.465	2.323	2.526	2.298	2.296
Magnesium, Mg (mg/l)	mg/L	<30	NS	**37.16**	**37.247**	**36.912**	**39.577**	**41.009**	**39.624**	12.796	**38.311**	**38.721**	**37.169**	**39.261**	**36.605**	**36.802**	**40.467**
Sodium, Na	mg/L	<100	<200	17.62	15.903	16.401	16.669	18.526	19.082	23.581	18.911	17.259	19.38	19.21	22.496	19.8	20.862
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.293	0.196	0.224	0.312	0.377	0.401	0.521	0.197	0.238	0.186	0.16	0.173	0.227	0.257
pH at 22 °C	pH units	6-9	5-9.7	8.336	8.286	8.195	8.204	8.222	8.237	7.88	8.202	8.581	8.198	8.21	8.27	8.275	8.198
Sulphate, SO_4	mg/L	<200	<500	78.949	68.647	71.072	74.349	77.811	75.389	58.143	87.038	80.198	82.44	85.786	94.458	87.587	89.808
Ammonium, NH_4	mg/L	<1.0	<1.5	0.066	0.061	0.049	0.055	0.047	0.054	0.077	0.02	0.043	0.02	0.041	0.02	0.096	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	60.32	63.87	68.38	68.70	68.07	72.92	36.89	58.63	63.92	62.76	58.97	52.93	63.19	65.21

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	27/03/2002	02/04/2002	10/04/2002	17/04/2002	22/04/2002	29/05/2002	05/06/2002	10/06/2002	20/06/2002	26/06/2002	10/07/2002	24/07/2002	07/08/2002	14/08/2002
Calcium, Ca	mg/L	<32	NS	51.341	59.251	56.452	55.547	52.399	54.745	58.59	57.524	61.878	62.637	60.4	60.985	60.714	60.997
Chloride, Cl	mg/L	<100	<300	21.569	22.693	22.652	22.649	22.133	24.482	25.256	25.997	23.862	22.819	23.747	21.828	23.793	23.406
Conductivity mS/m @ 25 °C	mS/m	<70	<170	65.7	66.9	64	62.8	64.9	66	66.8	66.6	66	65.6	64.4	65.2	65.9	68
Fluoride, F	mg/L	1	1.5	0.198	0.153	0.171	0.22	0.158	0.113	0.152	0.147	0.148	0.157	0.148	0.178	0.164	0.168
Potassium, K	mg/L	<50	NS	2.199	2.054	2.371	2.082	2.295	2.354	2.373	2.531	2.249	2.264	2.521	2.464	2.177	2.384
Magnesium, Mg (mg/l)	mg/L	<30	NS	44.292	45.1	41.295	41.267	44.549	43.368	41.924	41.026	42.295	41.917	43.643	44.902	42.328	42.236
Sodium, Na	mg/L	<100	<200	19.119	16.753	19.234	19.665	21.791	20.503	19.52	20.987	20.725	20.885	20.625	21.36	22.039	20.68
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.338	0.34	0.315	0.296	0.284	0.285	0.246	0.277	0.329	0.362	0.381	0.371	0.335	0.44
pH at 22 °C	pH units	6-9	5-9.7	8.268	8.242	8.732	8.813	8.35	8.243	8.334	8.401	8.39	8.424	8.374	8.299	8.099	8.343
Sulphate, SO_4	mg/L	<200	<500	79.012	85.92	88.892	93.666	91.927	90.172	102.101	93.544	87.943	82.901	94.084	93.678	94.514	95.978
Ammonium, NH_4	mg/L	<1.0	<1.5	0.149	0.02	0.02	0.058	0.058	0.02	0.02	0.02	0.02	0.043	0.02	0.056	0.491	0.05
Bicarbonate as $CaCO_3$	mg/L	NS	NS	62.64	72.29	68.87	67.77	63.93	66.79	71.48	70.18	75.49	76.42	73.69	74.40	74.07	74.42

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	04/09/2002	11/09/2002	18/09/2002	02/10/2002	09/10/2002	01/11/2002	06/11/2002	13/11/2002	20/11/2002	27/11/2002	03/12/2002	10/12/2002	17/12/2002	24/12/2002
Calcium, Ca	mg/L	<32	NS	64.346	46.014	31.552	62.909	61.487	61.244	58.085	57.855	69.412	67.849	65.124	72.21	59.603	56.878
Chloride, Cl	mg/L	<100	<300	24.15	22.535	26.711	22.497	23.766	24.728	23.022	24.35	22.45	20.48	24.44	21.621	25.921	23.85
Conductivity mS/m @ 25 °C	mS/m	<70	<170	68.4	64.7	58	72.7	71.9	72.1	70.6	67.8	76.2	73.4	74.3	83.4	71.7	71.1
Fluoride, F	mg/L	1	1.5	0.127	0.152	0.158	0.128	0.172	0.144	0.14	0.135	0.17	0.156	0.142	0.13	0.155	0.149
Potassium, K	mg/L	<50	NS	2.415	2.241	2.411	1.962	2.429	1.897	1.986	1.862	1.786	1.631	1.741	2.231	2.038	1.842
Magnesium, Mg (mg/l)	mg/L	<30	NS	40.161	43.92	41.936	44.874	41.781	42.879	47.705	42.949	46.521	47.026	45.875	51.254	44.605	43.237
Sodium, Na	mg/L	<100	<200	22.124	22.522	19.378	20.716	19.671	21.499	20.98	22.252	19.626	16.601	21.779	20.047	21.873	20.191
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.517	0.237	0.553	0.51	0.407	0.461	0.447	0.416	0.592	0.503	0.446	0.288	0.29	0.268
pH at 22 °C	pH units	6-9	5-9.7	8.246	7.946	8.251	8.318	8.27	8.305	8.516	8.271	8.334	8.426	8.362	8.661	8.437	8.43
Sulphate, SO_4	mg/L	<200	<500	93.849	89.645	97.911	90.231	95.471	109.335	96.88	98.078	97.887	85.926	92.743	130.338	109.596	99.577
Ammonium, NH_4	mg/L	<1.0	<1.5	0.064	0.02	0.124	0.043	0.071	0.143	0.08	0.02	0.02	0.02	0.056	0.059	0.044	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	78.50	56.14	38.49	76.75	75.01	74.72	70.86	70.58	84.68	82.78	79.45	88.10	72.72	69.39

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	06/01/2003	13/01/2003	21/01/2003	28/01/2003	04/02/2003	11/02/2003	18/02/2003	25/02/2003	04/03/2003	11/03/2003	18/03/2003	25/03/2003	01/04/2003	08/04/2003
Calcium, Ca	mg/L	<32	NS	54.363	50.68	56.08	68.836	67.628	50.892	61.96	64.99	63.337	66.481	65.063	70.436	66.512	64.033
Chloride, Cl	mg/L	<100	<300	24.03	22.282	22.176	18.845	18.794	25.322	23.975	21.778	22.655	19.919	19.652	21.119	21.688	21.924
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69.1	68.2	69.8	72.8	76.1	71.2	73.5	74	70.3	71.9	70.6	76.6	73.1	72.9
Fluoride, F	mg/L	1	1.5	0.14	0.132	0.136	0.157	0.182	0.129	0.156	0.179	0.176	0.165	0.176	0.194	0.211	0.168
Potassium, K	mg/L	<50	NS	1.709	1.747	1.946	1.788	1.719	1.852	1.414	1.497	1.463	1.425	1.304	1.987	1.38	1.485
Magnesium, Mg (mg/l)	mg/L	<30	NS	48.093	45.011	44.47	48.817	44.912	47.151	47.321	46.83	48.515	49.719	47.497	53.638	52.287	49.711
Sodium, Na	mg/L	<100	<200	18.686	19.093	17.825	15.472	16.465	18.026	14.909	17.656	16.49	14.44	15.215	15.734	14.6	16.015
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.312	0.276	0.345	0.532	0.613	0.242	0.4	0.466	0.347	0.51	0.551	0.503	0.305	0.149
pH at 22 °C	pH units	6-9	5-9.7	8.302	8.284	8.251	8.005	8.14	8.184	8.14	8.186	8.082	8.239	7.994	8.242	8.257	8.318
Sulphate, SO_4	mg/L	<200	<500	97.293	98.719	95.384	74.712	77.09	106.688	79.315	78.384	91.735	78.594	78.02	87.02	78.609	74.127
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.048	0.047	0.02	0.043	0.06	0.068	0.052	0.06	0.041	0.057	0.02	0.045
Bicarbonate as $CaCO_3$	mg/L	NS	NS	66.32	61.83	68.42	83.98	82.51	62.09	75.59	79.29	77.27	81.11	79.38	85.93	81.14	78.12

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	15/04/2003	30/04/2003	06/05/2003	14/05/2003	20/05/2003	27/05/2003	02/06/2003	10/06/2003	19/06/2003	25/06/2003	01/07/2003	08/07/2003	15/07/2003	22/07/2003
Calcium, Ca	mg/L	<32	NS	72.967	73.505	72.372	72.402	70.738	69.834	59.556	61.853	61.278	58.743	59.189	54.403	57.65	59.832
Chloride, Cl	mg/L	<100	<300	20.722	22.19	21.001	21.628	21.002	19.178	24.19	22.088	22.424	23.668	21.512	23.165	22.412	24.255
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69.6	69.1	73.7	73.5	72.7	72.2	72.3	73.4	69.6	68.6	68.7	67.7	71.6	69.7
Fluoride, F	mg/L	1	1.5	0.173	0.18	0.178	0.215	0.188	0.192	0.192	0.148	0.143	0.208	0.192	0.18	0.161	0.141
Potassium, K	mg/L	<50	NS	1.51	1.379	1.356	1.323	1.537	1.439	2.262	1.721	1.75	1.638	1.879	1.689	1.616	1.964
Magnesium, Mg (mg/l)	mg/L	<30	NS	47.431	45.92	46.978	49.057	47.603	46.558	48.273	48.164	46.926	43.69	45.193	46.395	47.928	47.491
Sodium, Na	mg/L	<100	<200	14.724	14.425	15.082	15.534	16.73	16.221	21.473	22.874	22.044	18.926	19.083	18.777	17.802	19.849
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.634	0.594	0.607	0.584	0.539	0.544	0.241	0.29	0.21	0.125	0.175	0.163	0.225	0.239
pH at 22 °C	pH units	6-9	5-9.7	8.12	8.039	8.071	8.217	8.128	8.035	8.173	8.176	8.193	8.296	8.274	8.263	8.241	8.396
Sulphate, SO_4	mg/L	<200	<500	77.634	79.202	79.631	83.244	77.989	78.045	123.157	124.539	106.385	106.601	104.593	100.995	92.262	93.45
Ammonium, NH_4	mg/L	<1.0	<1.5	0.065	0.077	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.041	0.02	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	89.02	89.68	88.29	88.33	86.30	85.20	72.66	75.46	74.76	71.67	72.21	66.37	70.33	73.00

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	30/07/2003	05/08/2003	12/08/2003	20/08/2003	27/08/2003	02/09/2003	09/09/2003	16/09/2003	30/09/2003	14/10/2003	21/10/2003	28/10/2003	04/11/2003	12/11/2003
Calcium, Ca	mg/L	<32	NS	60.753	55.614	53.766	57.389	64.094	56.197	52.42	62.916	70.49	69.45	70.314	73.927	69.596	66.927
Chloride, Cl	mg/L	<100	<300	25.679	24.726	26.738	23.262	23.109	20.602	22.917	22.335	22.716	21.119	22.46	21.561	21.3	20.649
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69.4	70.9	69.4	71.3	72.8	70	68.7	72.4	74.4	72.6	75.6	75	75	74.7
Fluoride, F	mg/L	1	1.5	0.141	0.181	0.208	0.177	0.1	0.21	0.166	0.207	0.222	0.197	0.19	0.1	0.1	0.1
Potassium, K	mg/L	<50	NS	1.683	1.738	2.013	2.051	1.976	1.981	2.041	1.979	1.953	1.646	1.971	2.958	1.797	1.634
Magnesium, Mg (mg/l)	mg/L	<30	NS	44.609	52.073	49.253	49.199	46.941	49.092	48.153	46.672	47.226	51.3	50.754	51.308	49.067	48.01
Sodium, Na	mg/L	<100	<200	21.789	22.412	22.233	20.395	19.359	17.619	22.864	18.615	16.682	18.524	18.071	18.702	18.733	21.685
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.181	0.2	0.25	0.202	0.197	0.264	0.02	0.255	0.064	0.02	0.162	0.055	0.055	0.055
pH at 22 °C	pH units	6-9	5-9.7	8.314	8.271	8.197	8.214	8.292	8.265	8.68	8.259	8.51	8.445	8.173	8.249	8.224	8.154
Sulphate, SO_4	mg/L	<200	<500	91.069	106.405	100.183	105.4	99.335	92.24	93.287	92.069	84.321	82.649	84.439	77.693	66.78	70.931
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.02	0.05	0.032	0.02	0.02	0.02	0.02	0.02	0.02	0.015	0.015	0.015
Bicarbonate as $CaCO_3$	mg/L	NS	NS	74.12	67.85	65.59	70.01	78.19	68.56	63.95	76.76	86.00	84.73	85.78	90.19	84.91	81.65

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	18/11/2003	26/11/2003	04/12/2003	17/12/2003	23/12/2003	30/12/2003	06/01/2004	14/01/2004	04/02/2004	03/03/2004	10/03/2004	25/03/2004	08/04/2004	13/04/2004
Calcium, Ca	mg/L	<32	NS	68.594	70.318	72.696	72.418	68.684	70.636	68.946	69.708	62.201	84.164	67.228	55.947	60.315	60.035
Chloride, Cl	mg/L	<100	<300	21.91	22.503	21.569	21.032	21.046	22.858	22.771	20.653	20.367	29.798	27.313	21.715	18.804	18.932
Conductivity mS/m @ 25 °C	mS/m	<70	<170	74.1	76.3	76.2	72.7	73	74.2	75.9	73.3	74.7	85.1	82.8	65.2	69.4	68.3
Fluoride, F	mg/L	1	1.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.201	0.1	0.1	0.1	0.1	0.1	0.1
Potassium, K	mg/L	<50	NS	1.848	2.329	1.55	1.376	1.455	1.819	1.733	1.551	1.563	2.374	2.72	2.497	2.191	2.168
Magnesium, Mg (mg/l)	mg/L	<30	NS	49.423	52.53	46.85	52.119	49.807	52.071	49.786	50.618	51.025	61.108	52.269	41.222	43.202	42.798
Sodium, Na	mg/L	<100	<200	18.122	19.487	17.267	15.959	19.822	17.298	20.997	20.919	19.509	15.386	18.861	17.824	19.033	18.604
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.055	0.055	0.055	0.055	0.055	0.055	0.15	0.2	0.188	0.224	0.264	0.176	0.055	0.34
pH at 22 °C	pH units	6-9	5-9.7	8.146	8.101	8.206	8.28	8.2	8.161	8.227	8.176	8.261	8.041	8.03	7.979	8.262	8.231
Sulphate, SO_4	mg/L	<200	<500	84.561	79.223	79.711	75.988	85.469	88.848	86.662	83.675	98.277	118.995	104.889	89.153	99.738	94.897
Ammonium, NH_4	mg/L	<1.0	<1.5	0.044	0.046	0.034	0.036	0.047	0.059	0.052	0.015	0.057	0.117	0.015	0.015	0.015	0.015
Bicarbonate as $CaCO_3$	mg/L	NS	NS	83.68	85.79	88.69	88.35	83.79	86.18	84.11	85.04	75.89	102.68	82.02	68.26	73.58	73.24

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	28/04/2004	05/05/2004	12/05/2004	19/05/2004	26/05/2004	31/05/2004	09/06/2004	23/06/2004	05/07/2004	12/07/2004	21/07/2004	28/07/2004	04/08/2004	18/08/2004
Calcium, Ca	mg/L	<32	NS	62.266	57.004	65.258	64.727	64.105	62.14	62.403	62.696	66.607	65.448	57.776	62.474	52.942	61.843
Chloride, Cl	mg/L	<100	<300	20.941	23.655	23.994	22.532	21.458	22.405	22.125	20.511	23.93	22.539	20.352	25.084	18.981	23.253
Conductivity mS/m @ 25 °C	mS/m	<70	<170	72.3	70.3	70.1	72.5	71.3	69.1	72	72.3	71.5	71.3	71.8	72.8	71.1	71.9
Fluoride, F	mg/L	1	1.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Potassium, K	mg/L	<50	NS	2.041	1.988	2.131	2.051	1.849	2.031	1.726	1.638	1.809	1.925	1.698	1.681	1.857	1.66
Magnesium, Mg (mg/l)	mg/L	<30	NS	47.648	46.459	46.601	49.713	43.689	44.188	47.004	46.955	44.066	44.567	46.309	47.217	47.724	46.695
Sodium, Na	mg/L	<100	<200	20.53	24.395	19.442	19.635	19.811	19.373	19.328	19.061	23.674	20.123	18.949	17.567	18.81	18.639
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.454	0.446	0.354	0.346	0.407	0.32	0.376	0.389	0.361	0.381	0.322	0.341	0.369	0.37
pH at 22 °C	pH units	6-9	5-9.7	8.045	8.205	8.325	8.171	8.245	8.226	8.191	8.232	8.195	8.153	8.155	8.197	8.282	8.168
Sulphate, SO_4	mg/L	<200	<500	88.804	100.553	102.567	101.795	93.627	115.856	100.289	95.121	104.503	95.377	93.603	91.771	95.664	89.968
Ammonium, NH_4	mg/L	<1.0	<1.5	0.044	0.045	0.05	0.072	0.07	0.015	0.015	0.015	0.033	0.031	0.015	0.015	0.047	0.039
Bicarbonate as $CaCO_3$	mg/L	NS	NS	75.96	69.54	79.61	78.97	78.21	75.81	76.13	76.49	81.26	79.85	70.49	76.22	64.59	75.45

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	25/08/2004	01/09/2004	08/09/2004	15/09/2004	29/09/2004	06/10/2004	13/10/2004	20/10/2004	27/10/2004	03/11/2004	10/11/2004	17/11/2004	24/11/2004	01/12/2004
Calcium, Ca	mg/L	<32	NS	63.583	62.532	64.701	61.03	65.122	64.86	64.334	65.288	62.244	63.072	60.864	52.282	64.393	63.335
Chloride, Cl	mg/L	<100	<300	23.131	20.399	20.814	24.17	19.212	20.238	20.194	23.174	20.462	19.296	20.493	19.695	22.376	20.472
Conductivity mS/m @ 25 °C	mS/m	<70	<170	73.3	69.4	71.9	71.4	71.5	72.1	73.8	73.6	71.8	73.6	74.3	69.4	72.6	69.6
Fluoride, F	mg/L	1	1.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Potassium, K	mg/L	<50	NS	1.67	1.906	1.752	1.656	1.618	1.724	1.619	1.38	1.62	1.408	1.355	13.889	1.373	1.987
Magnesium, Mg (mg/l)	mg/L	<30	NS	45.462	39.177	47.243	46.713	46.023	50.458	49.537	47.789	45.763	48.407	48.378	19.342	49.599	49.227
Sodium, Na	mg/L	<100	<200	17.634	19.483	20.364	17.916	17.755	17.843	15.861	16.51	18.091	17.194	16.679	63.954	16.942	17.822
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.466	0.329	0.38	0.581	0.358	0.218	0.264	0.286	0.159	0.178	0.171	0.17	0.204	0.172
pH at 22 °C	pH units	6-9	5-9.7	8.238	8.264	8.244	8.164	8.282	8.105	8.057	8.167	8.044	8.115	8.272	8.345	8.191	8.083
Sulphate, SO_4	mg/L	<200	<500	80.266	102.386	94.229	85.082	82.978	101.279	76.809	69.819	83.339	75.073	81.578	75.856	85.621	87.096
Ammonium, NH_4	mg/L	<1.0	<1.5	0.05	0.015	0.057	0.015	0.046	0.047	0.05	0.033	0.046	0.015	0.039	0.043	0.04	0.033
Bicarbonate as $CaCO_3$	mg/L	NS	NS	77.57	76.29	78.94	74.46	79.45	79.13	78.49	79.65	75.94	76.95	74.25	63.78	78.56	77.27

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	08/12/2004	15/12/2004	30/12/2004	05/01/2005	12/01/2005	19/01/2005	26/01/2005	16/02/2005	02/03/2005	09/03/2005	24/03/2005	31/03/2005	06/04/2005	13/04/2005
Calcium, Ca	mg/L	<32	NS	**59.709**	**49.248**	**62.99**	**65.626**	**59.28**	**65.972**	**46.404**	**64.244**	**69.194**	**71.353**	**39.299**	**50.008**	**51.023**	**51.452**
Chloride, Cl	mg/L	<100	<300	25.329	16.231	20.649	23.472	25.807	21.667	23.321	22.071	20.477	22.455	20.005	22.965	22.865	22.008
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69.9	56.6	**75.9**	**75.4**	**72.4**	**73.9**	66.3	**72.3**	**73.3**	**72.6**	57.6	64.9	63.6	65.7
Fluoride, F	mg/L	1	1.5	0.1	0.21	0.1	0.1	0.1	0.1	0.1	0.169	0.177	0.181	0.16	0.191	0.157	0.145
Potassium, K	mg/L	<50	NS	1.904	2.346	1.783	1.694	3.007	2.559	2.007	1.854	1.915	1.723	4.106	1.955	2.06	1.914
Magnesium, Mg (mg/l)	mg/L	<30	NS	**50.624**	**37.281**	**48.875**	**48.397**	**46.912**	**49.379**	**44.496**	**48.748**	**52.008**	**45.672**	**34.217**	**45.038**	**42.193**	**42.813**
Sodium, Na	mg/L	<100	<200	20.173	14.978	18.556	17.413	17.33	16.567	19.822	16.658	17.285	17.495	16.28	18.098	17.167	17.424
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.198	0.28	0.265	0.226	0.203	0.269	0.055	0.318	0.419	0.287	0.141	0.04	0.194	0.257
pH at 22 °C	pH units	6-9	5-9.7	8.391	7.907	8.069	8.073	7.964	8.12	7.942	8.035	8.193	8.137	7.996	7.744	8.022	8.065
Sulphate, SO_4	mg/L	<200	<500	98.204	78.803	97.657	82.437	79.631	65.751	110.225	79.207	74.152	90.574	72.529	96.231	91.55	85.166
Ammonium, NH_4	mg/L	<1.0	<1.5	0.064	0.083	0.045	0.148	0.031	0.039	0.015	0.059	0.059	0.046	0.041	0.02	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	72.84	60.08	76.85	80.06	72.32	80.49	56.61	78.38	84.42	87.05	47.94	61.01	62.25	62.77

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	20/04/2005	04/05/2005	11/05/2005	01/06/2005	08/06/2005	15/06/2005	22/06/2005	01/07/2005	06/07/2005	13/07/2005	20/07/2005	27/07/2005	03/08/2005	10/08/2005
Calcium, Ca	mg/L	<32	NS	**53.861**	**49.632**	**54.748**	**55.752**	**58.059**	**62.858**	**58.154**	**59.714**	**61.935**	**55.651**	**63.571**	**62.758**	**63.964**	**64.205**
Chloride, Cl	mg/L	<100	<300	21.773	21.821	19.842	21.668	18.753	22.741	21.364	20.897	24.137	21.238	21.289	21.814	21.918	24.189
Conductivity mS/m @ 25 °C	mS/m	<70	<170	65.1	64.9	67.2	68.4	65.2	**71.2**	69.4	69.9	69.1	**70.1**	**71.5**	**70.3**	**71.3**	**71.4**
Fluoride, F	mg/L	1	1.5	0.129	0.135	0.165	0.141	0.112	0.154	0.143	0.158	0.127	0.19	0.143	0.149	0.05	0.137
Potassium, K	mg/L	<50	NS	2.194	2.293	2.326	2.25	2.124	2.054	1.922	1.89	1.8	1.766	1.887	2.427	1.9	1.867
Magnesium, Mg (mg/l)	mg/L	<30	NS	**41.745**	**43.506**	**44.067**	**44.739**	**43.431**	**49.485**	**45.581**	**45.5**	**46.308**	**48.851**	**46.126**	**45.526**	**45.652**	**45.056**
Sodium, Na	mg/L	<100	<200	17.212	17.45	18.16	18.242	19.259	19.883	18.212	18.77	17.714	17.411	17.723	18.071	18.602	18.312
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.205	0.325	0.223	0.38	0.297	0.372	0.335	0.388	0.322	0.41	2.285	0.395	0.378	0.383
pH at 22 °C	pH units	6-9	5-9.7	7.7	8.089	7.975	8.283	8.354	8.106	8.102	8.235	8.208	8.14	8.186	8.258	8.245	8.177
Sulphate, SO_4	mg/L	<200	<500	85.724	79.181	85.838	92.056	89.463	90.339	85.568	79.069	83.999	89.616	83.877	83.205	94.859	85.207
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.02	0.02	0.02	0.02	0.045	0.049	0.02	0.062	0.02	0.05	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	65.71	60.55	66.79	68.02	70.83	76.69	70.95	72.85	75.56	67.89	77.56	76.56	78.04	78.33

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	17/08/2005	24/08/2005	31/08/2005	08/09/2005	14/09/2005	21/09/2005	28/09/2005	05/10/2005	19/10/2005	26/10/2005	02/11/2005	09/11/2005	16/11/2005	23/11/2005
Calcium, Ca	mg/L	<32	NS	64.555	66.899	61.669	65.646	60.396	65.052	64.007	67.071	63.997	59.458	68.437	58.896	59.146	62.995
Chloride, Cl	mg/L	<100	<300	23.741	25.134	23.55	23.78	22.423	22.97	23.492	21.52	19.705	26.464	20.023	23.197	22.572	21.369
Conductivity mS/m @ 25 °C	mS/m	<70	<170	73.5	71.9	72	72.6	73.3	74	73	72.5	73.8	69.8	73.1	71.3	72.5	71.8
Fluoride, F	mg/L	1	1.5	0.166	0.125	0.133	0.134	0.142	0.143	0.159	0.133	0.138	0.133	0.154	0.126	0.151	0.148
Potassium, K	mg/L	<50	NS	1.872	2.11	2.178	2.015	2.26	1.999	1.786	1.44	1.48	2.072	1.564	1.634	1.593	1.783
Magnesium, Mg (mg/l)	mg/L	<30	NS	47.844	43.576	45.7	50.861	47.286	50.26	51.038	49.088	47.746	46.277	47.564	48.011	48.909	49.147
Sodium, Na	mg/L	<100	<200	18.629	17.951	18.066	16.538	18.645	16.857	17.93	16.924	17.939	19.01	16.141	19.641	18.377	18.201
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.385	0.389	0.328	0.406	0.363	0.52	0.468	0.338	0.263	0.218	0.29	0.204	0.21	0.239
pH at 22 °C	pH units	6-9	5-9.7	8.336	8.185	8.254	8.264	8.121	8.119	8.548	8.252	8.057	8.401	8.051	8.085	8.283	8.385
Sulphate, SO_4	mg/L	<200	<500	85.155	91.28	85.267	90.412	80.342	75.906	76.2	77.718	64.468	87.032	79.541	93.029	83.714	76.189
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.048	0.041	0.059	0.065	0.05	0.063	0.067	0.02	0.02	0.075	0.041	0.067	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	78.76	81.62	75.24	80.09	73.68	79.36	78.09	81.83	78.08	72.54	83.49	71.85	72.16	76.85

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	30/11/2005	07/12/2005	15/12/2005	05/01/2006	11/01/2006	18/01/2006	01/02/2006	08/02/2006	15/02/2006	22/02/2006	02/03/2006	08/03/2006	15/03/2006	29/03/2006
Calcium, Ca	mg/L	<32	NS	56.102	59.981	49.527	71.368	68.213	70.451	70.007	72.751	78.852	76.901	54.842	58.176	65.533	57.071
Chloride, Cl	mg/L	<100	<300	20.741	23.292	27.755	23.28	23.732	23.18	26.941	31.217	33.418	25.139	27.482	33.902	26.473	24.489
Conductivity mS/m @ 25 °C	mS/m	<70	<170	71	72	68.4	73.8	72.7	71.3	75.9	84.4	88.2	80.5	68.6	78.5	73.3	66.8
Fluoride, F	mg/L	1	1.5	0.13	0.153	0.162	0.133	0.138	0.161	0.156	0.154	0.164	0.167	0.05	0.205	0.132	0.13
Potassium, K	mg/L	<50	NS	1.686	1.472	1.865	1.608	2.019	1.418	1.949	2.459	2.107	1.67	2.551	3.157	1.882	1.471
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.968	47.893	45.96	47.096	47.557	47.804	54.641	61.853	70.7	57.113	50.404	52.985	52.817	48.642
Sodium, Na	mg/L	<100	<200	16.719	17.01	21.319	16.877	16.543	16.742	19.552	21.564	22.536	18.262	20.957	25.137	19.521	21.241
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.233	0.171	0.148	0.224	0.274	0.23	0.224	0.252	0.197	0.26	0.04	0.204	0.231	0.158
pH at 22 °C	pH units	6-9	5-9.7	8.292	8.212	8.032	8.287	8.329	8.407	8.359	8.296	8.321	8.23	8.052	8.55	8.132	8.118
Sulphate, SO_4	mg/L	<200	<500	78.829	84.92	125.872	77.71	84.093	74.925	109.842	108.362	123.868	81.928	107.503	115.312	106.718	98.203
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.046	0.06	0.048	0.05	0.061	0.064	0.1	0.02	0.071	0.02	1.577	0.041	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	68.44	73.18	60.42	87.07	83.22	85.95	85.41	88.76	96.20	93.82	66.91	70.97	79.95	69.63

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	05/04/2006	12/04/2006	19/04/2006	03/05/2006	17/05/2006	24/05/2006	31/05/2006	07/06/2006	14/06/2006	21/06/2006	28/06/2006	05/07/2006	12/07/2006	19/07/2006
Calcium, Ca	mg/L	<32	NS	56.416	51.893	63.162	58.971	58.14	61.258	58.517	60.81	57.951	61.148	55.321	62.455	64.243	63.048
Chloride, Cl	mg/L	<100	<300	23.993	24.589	26.954	22.284	22.383	22.757	21.593	22.85	23.161	21.199	20.548	23.295	21.756	21.772
Conductivity mS/m @ 25 °C	mS/m	<70	<170	65.4	59.3	67.2	64.8	63.3	67.3	68.2	68.8	67.8	68.7	68.2	66.2	68.8	65.3
Fluoride, F	mg/L	1	1.5	0.141	0.148	0.153	0.162	0.117	0.161	0.159	0.149	0.161	0.187	0.149	0.147	0.154	0.144
Potassium, K	mg/L	<50	NS	2.025	3.576	2.769	2.63	2.229	2.146	2.118	2.111	2.111	2.2	2.04	1.881	1.901	1.589
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.083	37.106	44.463	44.97	41.942	46.049	44.871	45.955	44.963	46.442	46.039	42.154	47.769	46.332
Sodium, Na	mg/L	<100	<200	20.748	17.544	19.794	18.525	18.003	17.49	14.609	16.179	16.736	17.34	16.439	17.881	18.759	16.704
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.165	0.04	0.191	0.245	0.266	0.31	0.312	0.301	0.299	0.365	0.395	0.388	0.439	0.418
pH at 22 °C	pH units	6-9	5-9.7	8.042	8.089	8.118	8.262	8.442	8.642	8.26	8.253	8.287	8.358	8.239	8.258	8.236	8.334
Sulphate, SO_4	mg/L	<200	<500	102.369	93.986	105.608	75.416	75.581	91.626	84.374	85.004	84.557	92.814	86.121	81.285	91.454	88.242
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.02	0.104	0.041	0.046	0.02	0.12	0.02	0.02	0.055	0.02	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	68.83	63.31	77.06	71.94	70.93	74.73	71.39	74.19	70.70	74.60	67.49	76.20	78.38	76.92

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	26/07/2006	02/08/2006	16/08/2006	23/08/2006	30/08/2006	06/09/2006	13/09/2006	20/09/2006	27/09/2006	04/10/2006	11/10/2006	20/10/2006	25/10/2006	01/11/2006
Calcium, Ca	mg/L	<32	NS	63.269	56.339	58.3	58.398	60.396	60.068	53.929	63.431	64.517	66.379	60.145	64.994	59.199	68.303
Chloride, Cl	mg/L	<100	<300	20.791	22.787	22.164	24.372	22.024	22.855	22.741	23.953	22.515	19.708	21.87	20.867	23.084	23.905
Conductivity mS/m @ 25 °C	mS/m	<70	<170	65.3	65.5	67.3	65.5	66.1	63.6	65.7	70.2	63.8	66.6	64.2	70.7	71.3	72.9
Fluoride, F	mg/L	1	1.5	0.163	0.14	0.158	0.177	0.136	0.135	0.118	0.168	0.284	0.324	0.169	0.247	0.183	0.182
Potassium, K	mg/L	<50	NS	1.823	2.675	1.939	2.091	1.966	2.045	1.927	1.702	1.686	1.132	1.529	1.432	3.007	2.204
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.641	45.148	43.781	44.889	45.63	44.864	48.588	44.513	46.448	48.087	44.647	48.131	46.707	50.663
Sodium, Na	mg/L	<100	<200	17.527	17.335	18.39	18.453	18.081	17.937	18.039	17.826	19.073	15.539	17.811	15.488	17.688	18.325
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.434	0.53	0.374	0.373	0.457	0.423	0.514	0.55	0.343	0.499	0.278	0.356	0.31	0.302
pH at 22 °C	pH units	6-9	5-9.7	8.25	8.357	8.331	8.35	8.333	8.309	8.349	8.406	8.192	8.224	8.267	8.363	8.673	8.131
Sulphate, SO_4	mg/L	<200	<500	81.225	96.918	89.42	84.677	83.463	90.521	90.749	90.993	96.634	73.308	76.803	77.886	79.859	99.175
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.054	0.02	0.057	0.075	0.15	0.077	0.062	0.05	0.07	0.041	0.126	0.071
Bicarbonate as $CaCO_3$	mg/L	NS	NS	77.19	68.73	71.13	71.25	73.68	73.28	65.79	77.39	78.71	80.98	73.38	79.29	72.22	83.33

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	08/11/2006	15/11/2006	22/11/2006	29/11/2006	06/12/2006	13/12/2006	20/12/2006	04/01/2007	10/01/2007	17/01/2007	24/01/2007	31/01/2007	07/02/2007	14/02/2007
Calcium, Ca	mg/L	<32	NS	**68.444**	**55.82**	**58.327**	**54.506**	**54.993**	**58.318**	**50.195**	**54.831**	**62.996**	**58.937**	**54.492**	**63.573**	**66.101**	**65.352**
Chloride, Cl	mg/L	<100	<300	24.075	28.584	23.54	26.011	23.007	21.866	21.379	22.669	22.104	23.622	24.961	19.928	21.065	20.139
Conductivity mS/m @ 25 °C	mS/m	<70	<170	**70.8**	68.9	**71**	66.2	67.9	68.5	58.8	67.7	67	67.1	66.5	67.9	69.9	**70.5**
Fluoride, F	mg/L	1	1.5	0.185	0.157	0.183	0.168	0.142	0.159	0.164	0.142	0.16	0.214	0.138	0.116	0.176	0.138
Potassium, K	mg/L	<50	NS	1.427	2.413	1.44	1.439	1.422	1.586	4.011	1.496	1.486	2.088	1.538	1.938	2.072	1.693
Magnesium, Mg (mg/l)	mg/L	<30	NS	**48.065**	**46.056**	**50.205**	**47.726**	**47.53**	**45.685**	**36.867**	**47.153**	**47.522**	**46.167**	**46.095**	**45.544**	**46.903**	**47.924**
Sodium, Na	mg/L	<100	<200	16.178	19.815	20.108	20.633	20.169	17.937	14.736	19.697	18.03	16.428	17.449	16.37	16.558	16.962
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.345	0.195	0.269	0.169	0.231	0.285	0.293	0.283	0.336	0.182	0.281	0.473	0.659	0.297
pH at 22 °C	pH units	6-9	5-9.7	8.321	8.31	8.148	8.125	8.365	8.316	8.205	8.344	8.216	8.181	8.14	8.312	8.276	8.356
Sulphate, SO_4	mg/L	<200	<500	90.449	109.101	94.81	106.779	86.751	84.387	71.652	90.223	85.478	78.436	82.919	77.339	70.211	75.423
Ammonium, NH_4	mg/L	<1.0	<1.5	0.051	0.066	0.093	0.042	0.02	0.091	0.02	0.1	0.068	0.066	0.19	0.157	0.119	0.125
Bicarbonate as $CaCO_3$	mg/L	NS	NS	83.50	68.10	71.16	66.50	67.09	71.15	61.24	66.89	76.86	71.90	66.48	77.56	80.64	79.73

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	21/02/2007	28/02/2007	07/03/2007	14/03/2007	28/03/2007	13/04/2007	18/04/2007	25/04/2007	02/05/2007	09/05/2007	16/05/2007	23/05/2007	01/06/2007	06/06/2007
Calcium, Ca	mg/L	<32	NS	**68.995**	**59.589**	**67.93**	**63.706**	**60.008**	**64.524**	**65.62**	**71.793**	**71.874**	**67.305**	**67.935**	**72.417**	**70.482**	**72.095**
Chloride, Cl	mg/L	<100	<300	19.353	20.455	22.495	21.733	23.239	23.355	22.342	30.68	22.108	24.454	21.49	24.166	22.825	24.621
Conductivity mS/m @ 25 °C	mS/m	<70	<170	**70**	**71.4**	**70.2**	**72.9**	**72.2**	68.6	**70.7**	**74.1**	**71.9**	**71.1**	**70.1**	67.1	**72.3**	**73.3**
Fluoride, F	mg/L	1	1.5	0.173	0.207	0.168	0.155	0.174	0.124	0.117	0.128	0.134	0.142	0.146	0.148	0.115	0.166
Potassium, K	mg/L	<50	NS	1.618	1.692	1.975	2.187	1.756	1.639	1.558	1.643	1.336	1.411	1.569	2.299	1.549	3.12
Magnesium, Mg (mg/l)	mg/L	<30	NS	**50.492**	**45.882**	**44.299**	**48.229**	**46.832**	**49.594**	**46.157**	**48.552**	**47.983**	**46.083**	**46.597**	**47.617**	**48.051**	**46.931**
Sodium, Na	mg/L	<100	<200	15.32	16.545	15.962	17.316	15.615	18.24	16.495	14.902	14.873	16.33	15.212	17.435	17.804	15.649
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.287	0.283	0.318	0.281	0.327	0.423	0.395	0.6	0.44	0.474	0.389	0.329	0.483	0.338
pH at 22 °C	pH units	6-9	5-9.7	8.326	8.129	8.053	8.07	8.297	8.414	8.37	8.213	8.218	8.197	8.407	8.302	8.066	8.268
Sulphate, SO_4	mg/L	<200	<500	83.071	68.366	71.359	75.596	77.613	79.921	70.253	83.762	76.483	82.541	73.662	88.165	70.817	76.007
Ammonium, NH_4	mg/L	<1.0	<1.5	0.128	0.123	0.162	0.151	0.144	0.107	0.102	0.142	0.091	0.113	0.105	0.07	0.117	0.095
Bicarbonate as $CaCO_3$	mg/L	NS	NS	84.17	72.70	82.87	77.72	73.21	78.72	80.06	87.59	87.69	82.11	82.88	88.35	85.99	87.96

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	14/06/2007	20/06/2007	27/06/2007	04/07/2007	11/07/2007	18/07/2007	25/07/2007	01/08/2007	08/08/2007	16/08/2007	22/08/2007	29/08/2007	06/09/2007	12/09/2007
Calcium, Ca	mg/L	<32	NS	60.264	61.124	56.189	57.929	57.182	64.775	63.247	64.173	65.235	61.551	64.411	71.317	61.155	71.254
Chloride, Cl	mg/L	<100	<300	27.018	29.982	24.618	30.607	25.978	30.183	25.251	26.334	26.929	26.571	28.117	26.872	29.981	29.142
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69.4	65	70.2	71	70.2	65.1	70.5	72.3	79.2	73.7	73.1	75.1	74.7	73.7
Fluoride, F	mg/L	1	1.5	0.14	0.111	0.103	0.135	0.115	0.111	0.131	0.12	0.147	0.158	0.163	0.145	0.15	0.145
Potassium, K	mg/L	<50	NS	2.156	1.859	2.143	2.067	2.084	1.831	1.637	1.998	1.968	2.096	2.198	1.885	2.444	2.532
Magnesium, Mg (mg/l)	mg/L	<30	NS	49.323	47.253	47.032	48.111	48.433	47.687	46.919	46.844	48.755	45.174	47.272	47.422	48.066	44.538
Sodium, Na	mg/L	<100	<200	22.03	20.63	21.915	21.57	20.873	19.421	20.01	21.093	22.206	20.244	21.212	19.996	23.059	19.293
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.377	0.297	0.299	0.288	0.383	0.352	0.376	0.396	0.296	0.387	0.525	0.393	0.602	0.451
pH at 22 °C	pH units	6-9	5-9.7	8.341	8.202	8.271	8.057	8.177	8.26	8.206	8.156	8.451	8.24	8.242	8.222	8.15	8.039
Sulphate, SO_4	mg/L	<200	<500	105.613	108.056	108.726	105.549	99.863	102.094	96.39	85.945	103.106	110.257	107.628	90.803	99.41	87.129
Ammonium, NH_4	mg/L	<1.0	<1.5	0.088	0.119	0.226	0.093	0.119	0.093	0.096	0.075	0.098	0.201	0.127	0.103	0.084	0.138
Bicarbonate as $CaCO_3$	mg/L	NS	NS	73.52	74.57	68.55	70.67	69.76	79.03	77.16	78.29	79.59	75.09	78.58	87.01	74.61	86.93

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	19/09/2007	27/09/2007	03/10/2007	10/10/2007	17/10/2007	24/10/2007	31/10/2007	07/11/2007	14/11/2007	21/11/2007	28/11/2007	06/12/2007	21/12/2007	04/01/2008
Calcium, Ca	mg/L	<32	NS	63.287	62.975	63.817	67.463	65.292	62.401	66.051	67.195	65.197	65.307	60.345	55.706	58.555	61.282
Chloride, Cl	mg/L	<100	<300	25.034	29.54	30.263	25.829	27.911	26.258	28.965	30.738	26.153	27.577	24.386	24.805	28.665	21.588
Conductivity mS/m @ 25 °C	mS/m	<70	<170	75.2	78	75.6	74.8	71.5	74.1	74.6	68.8	68.9	69.1	68.8	70.7	72.3	69.3
Fluoride, F	mg/L	1	1.5	0.134	0.151	0.05	0.152	0.13	0.123	0.163	0.136	0.129	0.109	0.132	0.106	0.111	0.143
Potassium, K	mg/L	<50	NS	1.803	4.257	2.708	1.853	1.986	1.729	1.838	1.594	1.834	1.755	1.465	1.488	1.419	1.248
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.404	50.045	49.315	47.432	50.416	43.702	51.059	49.096	45.511	43.67	47.339	46.614	48.263	50.176
Sodium, Na	mg/L	<100	<200	17.704	19.489	25.625	21.966	19.201	20.937	20.88	20.518	15.138	23.21	15.611	17.889	20.528	20.569
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.341	0.537	0.425	0.35	0.354	0.28	0.277	0.234	0.252	0.242	0.215	0.182	0.16	0.275
pH at 22 °C	pH units	6-9	5-9.7	8.226	8.023	8.301	8.085	8.149	8.209	8.031	8.098	8.228	8.258	8.046	8.665	8.197	8.24
Sulphate, SO_4	mg/L	<200	<500	85.883	90.675	95.329	98.378	117.891	102.337	90.425	100.235	94.337	86.852	83.199	94.986	96.94	91.669
Ammonium, NH_4	mg/L	<1.0	<1.5	0.137	0.081	0.113	0.147	0.132	0.098	0.157	0.312	0.125	0.057	0.073	0.096	0.049	0.09
Bicarbonate as $CaCO_3$	mg/L	NS	NS	77.21	76.83	77.86	82.30	79.66	76.13	80.58	81.98	79.54	79.67	73.62	67.96	71.44	74.76

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	09/01/2008	16/01/2008	23/01/2008	30/01/2008	06/02/2008	13/02/2008	20/02/2008	27/02/2008	05/03/2008	12/03/2008	19/03/2008	27/03/2008	02/04/2008	09/04/2008
Calcium, Ca	mg/L	<32	NS	65.766	63.869	61.794	50.474	46.783	47.717	48.222	47.358	53.175	51.538	50.313	53.694	52.34	52.901
Chloride, Cl	mg/L	<100	<300	22.359	22.884	25.837	23.895	23.826	22.546	25.252	22.222	23.507	23.938	25.639	25.041	26.316	23.727
Conductivity mS/m @ 25 °C	mS/m	<70	<170	70	67.3	66.3	68.1	65.5	63.6	67.3	65	64	65.2	68.7	59.8	61	68.9
Fluoride, F	mg/L	1	1.5	0.147	0.136	0.141	0.145	0.142	0.116	0.14	0.142	0.136	0.13	0.148	0.127	0.167	0.132
Potassium, K	mg/L	<50	NS	2.148	1.442	2.654	1.6	1.819	1.84	1.883	2.13	1.958	1.974	2.588	2.069	1.873	2.061
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.323	48.233	47.6	42.661	42.958	46.326	45.617	41.2	44.679	46.062	48.001	43.884	43.19	44.331
Sodium, Na	mg/L	<100	<200	20.177	18.987	20.001	23.01	22.922	22.619	22.514	20.591	19.33	21.564	23.04	21.754	21.331	17.66
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.307	0.384	0.303	0.203	0.16	0.165	0.275	0.257	0.258	0.179	0.04	0.166	0.134	0.202
pH at 22 °C	pH units	6-9	5-9.7	8.014	8.274	8.405	8.112	8.166	8.264	8.529	8.079	8.379	8.181	8.219	8.262	8.24	8.589
Sulphate, SO_4	mg/L	<200	<500	82.975	90.11	81.111	104.113	110.239	97.844	89.174	94.405	82.63	89.379	93.339	93.281	89.187	89.947
Ammonium, NH_4	mg/L	<1.0	<1.5	0.207	0.183	0.116	0.135	0.119	0.147	0.165	0.09	0.149	0.162	0.148	0.164	0.126	0.067
Bicarbonate as $CaCO_3$	mg/L	NS	NS	80.23	77.92	75.39	61.58	57.08	58.21	58.83	57.78	64.87	62.88	61.38	65.51	63.85	64.54

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	16/04/2008	23/04/2008	30/04/2008	14/05/2008	10/09/2008	17/09/2008	08/10/2008	15/10/2008	23/10/2008	29/10/2008	05/11/2008	12/11/2008	19/11/2008	03/12/2008
Calcium, Ca	mg/L	<32	NS	53.684	54.366	52.032	53.942	66.069	56.1	62.6	54.4	54	56.4	64.738	66.053	65.233	63.903
Chloride, Cl	mg/L	<100	<300	24.127	22.458	22.893	23.77	29.729	28.1	25.3	25.9	26.4	27.5	27.168	30.953	26.497	26.34
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69.6	63	63.6	63	63.9	71.9	68.2	68.3	69.2	73.5	62.6	69	65.4	64.9
Fluoride, F	mg/L	1	1.5	0.124	0.127	0.126	0.128	-	0.05	0.05	0.05	0.05	0.05	-	-	-	-
Potassium, K	mg/L	<50	NS	2.084	2.107	1.906	2.096	1.39	1.48	0.862	0.15	0.15	0.659	1.738	1.674	1.532	0.562
Magnesium, Mg (mg/l)	mg/L	<30	NS	44.907	44.693	48.637	44.028	46.252	43.4	49.1	45.2	46.1	46.8	61.573	77.445	57.595	64.292
Sodium, Na	mg/L	<100	<200	21.706	20.719	21.87	21.353	14.886	18.5	19	17.6	19	18.2	11.957	19.558	11.648	15.394
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.261	0.361	0.327	0.27	-	0.34	0.29	0.25	0.24	0.29	0.338	0.36	-	0.34
pH at 22 °C	pH units	6-9	5-9.7	8.342	8.319	8.059	8.207	8.772	8.68	8.63	8.76	8.62	8.19	6.988	8.366	8.443	8.393
Sulphate, SO_4	mg/L	<200	<500	86.309	89.04	90.42	91.416	108.996	88.8	88.3	80.3	79.1	97.6	87.759	125.991	81.915	99.075
Ammonium, NH_4	mg/L	<1.0	<1.5	0.128	0.107	0.096	0.109	0.025	0.02	0.02	0.02	0.02	0.02	0.025	0	0.025	0
Bicarbonate as $CaCO_3$	mg/L	NS	NS	65.49	66.33	63.48	65.81	80.60	68.44	76.37	66.37	65.88	68.81	78.98	80.58	79.58	77.96

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	17/12/2008	24/12/2008	31/12/2008	07/01/2009	14/01/2009	28/01/2009	04/02/2009	18/02/2009	25/02/2009	04/03/2009	11/03/2009	18/03/2009	26/03/2009	01/04/2009
Calcium, Ca	mg/L	<32	NS	67.647	61.665	60.085	61.293	65.736	66.87	64.637	68.337	65.854	55.554	64.305	69.508	64.719	63.378
Chloride, Cl	mg/L	<100	<300	30.017	27.118	27.376	28.386	28.766	26.717	29.157	24.959	25.009	30.708	29.508	27.217	29.307	30.984
Conductivity mS/m @ 25 °C	mS/m	<70	<170	67.6	64.3	66.2	69	69.9	72.8	73	74.3	74.6	68.9	62.5	65.9	62	61.2
Fluoride, F	mg/L	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium, K	mg/L	<50	NS	1.091	1.099	0.738	1.946	2	1.9	2.4	2.541	2.3	2.734	1.4	1.4	1.4	1.8
Magnesium, Mg (mg/l)	mg/L	<30	NS	80.634	70.434	68.445	46.831	49.466	49.978	47.964	58.929	69.147	49.663	49.391	49.375	48.986	48.564
Sodium, Na	mg/L	<100	<200	20.698	17.599	16.546	17.673	19.8	18	22	16.278	17.1	22.617	16.9	19.7	17.1	19.7
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.379	0.29	0.519	-	-	-	-	0.359	-	0.112	-	-	-	-
pH at 22 °C	pH units	6-9	5-9.7	8.7	8.525	8.36	8.781	8.816	8.625	8.565	7.293	8.184	8.223	8.321	8.245	8.301	8.317
Sulphate, SO_4	mg/L	<200	<500	125.125	103.134	106.71	75.427	91.132	89.295	89.542	76.975	75.437	119.923	97.344	88.02	94.989	112.675
Ammonium, NH_4	mg/L	<1.0	<1.5	0	0	0	0.025	0.025	0.025	0.025	0.064	0.025	0.025	0.025	0.025	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	82.53	75.23	73.30	74.78	80.20	81.58	78.86	83.37	80.34	67.78	78.45	84.80	78.96	77.32

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	08/04/2009	16/04/2009	30/04/2009	06/05/2009	13/05/2009	03/06/2009	10/06/2009	26/08/2009	02/09/2009	16/09/2009	30/09/2009	07/10/2009	14/10/2009	21/10/2009
Calcium, Ca	mg/L	<32	NS	61.462	65.735	62.667	55.638	61.097	62.442	62.525	68.796	66.34	65.283	67.356	69.499	64.605	67.695
Chloride, Cl	mg/L	<100	<300	30.368	31.246	28.178	38.267	29.415	28.852	31.272	27.811	26.755	23.816	27.663	25.837	27.669	27.64
Conductivity mS/m @ 25 °C	mS/m	<70	<170	65.8	69.5	68.6	69.8	70.9	70.9	70.8	73.4	72.8	72.5	73.2	71	72.8	73
Fluoride, F	mg/L	1	1.5	-	-	-	-	0.151	0.159	-	-	-	-	-	-	-	-
Potassium, K	mg/L	<50	NS	1.7	1.9	2.184	1.266	2.483	2.521	3.433	2.498	1.5	2.311	1.737	1.549	1.6	1.7
Magnesium, Mg (mg/l)	mg/L	<30	NS	49.377	52.557	48.853	51.479	50.271	49.029	48.347	61.845	49.877	49.259	48.405	52.04	51.112	50.922
Sodium, Na	mg/L	<100	<200	21.9	22.2	20.42	20.356	19.884	20.217	22.269	19.812	18.2	18.51	15.386	18.079	19	19
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	-	-	0.387	0.061	0.168	0.328	0.304	-	-	0.45	-	-	-	-
pH at 22 °C	pH units	6-9	5-9.7	8.178	8.184	8.515	8.543	8.676	8.76	8.74	8.427	8.386	8.458	8.135	8.391	8.303	8.41
Sulphate, SO_4	mg/L	<200	<500	96.19	99.507	91.337	106.824	116.507	125.467	137.581	88.624	84.738	86.153	82.719	76.82	93.239	81.005
Ammonium, NH_4	mg/L	<1.0	<1.5	0.025	0.055	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.052	0.025	0.025	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	74.98	80.20	76.45	67.88	74.54	76.18	76.28	83.93	80.93	79.65	82.17	84.79	78.82	82.59

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	20/11/2009	25/11/2009	02/12/2009	16/12/2009	23/12/2009	06/01/2010	13/01/2010	27/01/2010	03/02/2010	10/02/2010	17/02/2010	24/02/2010	03/03/2010	10/03/2010
Calcium, Ca	mg/L	<32	NS	62.443	55.201	57.208	49.469	55.353	48.926	48.193	42.295	45.079	48.337	49.56	50.988	63.583	52.017
Chloride, Cl	mg/L	<100	<300	27.789	29.745	28.51	28.921	27.636	30.951	29.684	27.41	28.428	32.859	25.741	24.128	30.367	26.111
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69.6	67.1	68	64.9	65.5	64.3	67	62	63.4	63.6	63.8	63.4	64	65.4
Fluoride, F	mg/L	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium, K	mg/L	<50	NS	1.9	1.6	1.7	2.468	2.388	1.581	1.651	2.462	2.156	3.059	2.325	2.468	2.688	2.987
Magnesium, Mg (mg/l)	mg/L	<30	NS	47.997	48.043	48.145	44.004	48.642	46.273	46.372	42.193	43.834	50.598	42.466	43.615	53.045	49.022
Sodium, Na	mg/L	<100	<200	19.7	20.9	20.5	22.276	20.818	22.262	21.465	19.163	19.841	21.806	18.467	18.076	19.702	19.681
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	-	-	-	0.063	0.025	0.154	0.132	0.025	0.025	0.025	0.118	0.127	0.246	0.178
pH at 22 °C	pH units	6-9	5-9.7	8.293	8.388	8.318	8.433	7.664	8.097	7.278	8.255	8.278	8.237	8.317	8.131	8.159	8.469
Sulphate, SO_4	mg/L	<200	<500	86.736	101.574	97.024	105.231	88.328	113.334	110.323	93.702	98.262	98.493	86.304	90.627	92.573	76.193
Ammonium, NH_4	mg/L	<1.0	<1.5	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	76.18	67.35	69.79	60.35	67.53	59.69	58.80	51.60	55.00	58.97	60.46	62.21	77.57	63.46

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	17/03/2010	25/03/2010	31/03/2010	08/04/2010	14/04/2010	22/04/2010	28/04/2010	05/05/2010	26/05/2010	02/06/2010	16/06/2010	01/07/2010	04/08/2010	20/08/2010
Calcium, Ca	mg/L	<32	NS	54.565	52.936	57.081	54.35	54.436	57.515	52.007	55.945	50.339	51.6	55.465	59.243	58.652	59.647
Chloride, Cl	mg/L	<100	<300	26.548	25.898	26.997	25.639	25.443	26.092	25.913	25.406	16.853	17.464	18.641	21.355	21.686	22.779
Conductivity mS/m @ 25 °C	mS/m	<70	<170	65.4	65.8	67	65.1	64.8	66.1	63.7	-	54.7	56.1	56.8	59.9	62.6	-
Fluoride, F	mg/L	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-	0.293	0.098
Potassium, K	mg/L	<50	NS	2.738	2.477	2.96	3.085	2.981	3.498	2.961	3.617	3.384	2.467	2.405	3.385	3.036	3.731
Magnesium, Mg (mg/l)	mg/L	<30	NS	43.631	43.182	49.701	48.631	47.613	48.642	41.16	40.416	41.21	35.41	36.441	39.021	41.851	45.033
Sodium, Na	mg/L	<100	<200	17.627	17.152	19.365	18.356	18.292	17.645	17.764	19.577	16.309	14.525	17.047	16.742	18.096	17.078
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.625	0.177	0.136	0.099	0.138	0.14	0.182	0.116	0.104	0.025	0.087	0.337	0.381	0.464
pH at 22 °C	pH units	6-9	5-9.7	8.313	8.332	8.287	8.168	8.14	8.031	8.377	8.266	7.401	8.321	8.204	8.22	7.84	8.089
Sulphate, SO_4	mg/L	<200	<500	83.347	82.4	77.917	73.676	75.037	72.993	61.477	59.677	48.401	51.895	50.184	60.505	67.657	71.308
Ammonium, NH_4	mg/L	<1.0	<1.5	0.025	0.025	0.025	0.025	0.025	0.082	0.025	0.025	0.025	0.139	0.025	0.025	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	66.57	64.58	69.64	66.31	66.41	70.17	63.45	68.25	61.41	62.95	67.67	72.28	71.56	72.77

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	08/09/2010	22/09/2010	21/10/2010	03/11/2010	10/11/2010	24/11/2010	01/12/2010	22/12/2010	05/01/2011	26/01/2011	02/03/2011	09/03/2011	23/03/2011	13/04/2011
Calcium, Ca	mg/L	<32	NS	63.371	61.093	60.942	64.339	63.911	57.589	55.322	52.947	43.1	49.9	50.045	50.481	52.873	55.785
Chloride, Cl	mg/L	<100	<300	22.881	24.038	23.427	23.447	33.744	25.681	26.82	26.189	20.8	24	17.507	17.944	18.059	18.252
Conductivity mS/m @ 25 °C	mS/m	<70	<170	66.9	67.9	70.2	71.3	79.4	66	66.6	62	53.2	55.6	54.3	57.2	56	59.3
Fluoride, F	mg/L	1	1.5	0.226	0.18	0.219	0.362	0.187	0.292	0.168	0.08	0.025	0.107	0.236	0.322	0.228	0.112
Potassium, K	mg/L	<50	NS	2.274	2.238	2.759	2.212	4.081	2.242	1.96	2.536	3.48	3.08	2.66	2.627	2.511	2.512
Magnesium, Mg (mg/l)	mg/L	<30	NS	41.315	42.07	43.213	69.594	52.475	58.535	45.997	44.437	34.4	39.5	33.581	36.783	35.954	44.009
Sodium, Na	mg/L	<100	<200	20.416	16.14	17.645	18.229	24.865	19.528	18.59	22.216	16.1	18.8	17.001	16.346	17.2	18.186
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.343	0.301	0.429	0.09	0.025	0.22	0.245	0.069	0.05	0.07	0.139	0.025	0.025	0.067
pH at 22 °C	pH units	6-9	5-9.7	8.364	8.43	8.255	7.966	8.285	8.403	8.487	8.352	8.262	8.682	8.39	8.27	8.402	8.278
Sulphate, SO_4	mg/L	<200	<500	73.906	82.11	79.598	85.859	145.451	86.956	92.993	92.317	58.2	56.7	56.567	56.023	58.657	57.232
Ammonium, NH_4	mg/L	<1.0	<1.5	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	77.31	74.53	74.35	78.49	77.97	70.26	67.49	64.60	52.58	60.88	61.05	61.59	64.51	68.06

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	06/05/2011	25/05/2011	01/06/2011	23/06/2011	30/06/2011
Calcium, Ca	mg/L	<32	NS	58.801	59.494	61.335	58.808	46.097
Chloride, Cl	mg/L	<100	<300	20.525	19.61	20.585	22.078	19.976
Conductivity mS/m @ 25 °C	mS/m	<70	<170	62.4	56.4	61.7	61.6	58
Fluoride, F	mg/L	1	1.5	0.189	0.149	0.357	0.21	0.219
Potassium, K	mg/L	<50	NS	2.606	2.896	2.68	3.107	3.388
Magnesium, Mg (mg/l)	mg/L	<30	NS	38.656	35.013	39.981	40.181	35.959
Sodium, Na	mg/L	<100	<200	18.602	17.607	18.186	20.119	18.741
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.025	0.158	0.367	0.28	0.201
pH at 22 °C	pH units	6-9	5-9.7	7.851	8.373	8.208	8.245	8.293
Sulphate, SO_4	mg/L	<200	<500	61.192	59.094	61.18	63.324	56.675
Ammonium, NH_4	mg/L	<1.0	<1.5	0.025	0.025	0.025	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	71.74	72.58	74.83	71.75	56.24

Exceed the DWA SAWQTV standards
Exceed the SANS standards

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Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	04/01/1999	11/01/1999	14/01/1999	18/01/1999	25/01/1999	08/02/1999	15/02/1999	17/02/1999	22/02/1999	22/02/1999	01/03/1999	08/03/1999	12/03/1999	15/03/1999
Calcium, Ca	mg/L	**<32**	**NS**	**47**	**46.8**	**48.7**	**47.8**	**48.7**	**49.3**	**45.4**	**50.3**	**54.6**	**52.1**	**42.5**	**53.6**	**48.99**	**47.5**
Chloride, Cl	mg/L	**<100**	**<300**	31.4	38.6	42.3	43.6	47.9	56.4	20.3	47.2	43.5	50.2	34	58.1	40.758	42.9
Conductivity mS/m @ 25 °C	mS/m	**<70**	**<170**	62.5	63.5	67.3	67.2	69	**76.5**	61.4	69.5	**70.1**	**74**	57.8	**79.4**	**70.4**	69.6
Fluoride, F	mg/L	**1**	**1.5**	0.25	0.27	0.25	0.26	0.24	0.29	0.16	0.27	0.26	0.25	0.26	0.39	0.305	0.31
Potassium, K	mg/L	**<50**	**NS**	4.62	3.81	4.11	4.98	5.18	7.61	1.95	6.12	5.42	6.57	4.18	7.81	7.678	6.35
Magnesium, Mg (mg/l)	mg/L	**<30**	**NS**	**37.3**	**34.6**	**36**	**36.1**	**37.6**	**38.9**	**38.7**	**37.8**	**36.1**	**40.9**	**31.9**	**37.9**	**36.727**	**37.9**
Sodium, Na	mg/L	**<100**	**<200**	29.9	35.3	36.4	38.4	38.6	47	18.7	38.9	35.8	43.3	29.7	47.7	37.105	37.2
Nitrate, NO_2+NO_3	mg/L	**<26.6**	**<48.7**	0.02	0.051	0.481	0.334	0.642	1.259	0.02	0.441	0.655	0.699	0.02	0.02	0.494	0.504
pH at 22 °C	pH units	**6-9**	**5-9.7**	8.64	8.39	8.3	8.29	8.63	8.44	8.59	8.45	8.25	8.36	**9.14**	8.39	7.998	8.32
Sulphate, SO_4	mg/L	**<200**	**<500**	87.7	71.1	76.6	72.7	75.3	76.5	76.5	79	85	82.6	82.1	92.3	96.155	88.8
Ammonium, NH_4	mg/L	**<1.0**	**<1.5**	0.02	0.02	0.275	0.02	0.02	0.02	0.02	0.02	0.02	0.239	0.02	0.02	0.02	0.068
Bicarbonate as $CaCO_3$	mg/L	**NS**	**NS**	57.34	57.10	59.41	58.32	59.41	60.15	55.39	61.37	66.61	63.56	51.85	65.39	59.77	57.95

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	17/03/1999	23/03/1999	30/03/1999	06/04/1999	12/04/1999	19/04/1999	22/04/1999	26/04/1999	03/05/1999	10/05/1999	19/05/1999	24/05/1999	27/05/1999	31/05/1999
Calcium, Ca	mg/L	**<32**	**NS**	**49.329**	**54.4**	**54.3**	**53.7**	**56.2**	**61.5**	**58.455**	**55.215**	**54.4**	**59.403**	**59.2**	**53.9**	**56.6**	**59.5**
Chloride, Cl	mg/L	**<100**	**<300**	47.348	45.4	46.1	52.5	66.6	84.2	62.727	54.826	53.6	42.016	46.1	40.3	42.3	37.3
Conductivity mS/m @ 25 °C	mS/m	**<70**	**<170**	**74.7**	**74.3**	**76.6**	**79.6**	**86.3**	**95.4**	**75.7**	**80**	**77.9**	**77.9**	**79.6**	**76.7**	**76.5**	**76**
Fluoride, F	mg/L	**1**	**1.5**	0.33	0.24	0.25	0.29	0.31	0.67	0.408	0.3	0.27	0.231	0.23	0.22	0.19	0.19
Potassium, K	mg/L	**<50**	**NS**	7.365	5.8	6.41	6.27	6.42	8.46	8.049	5.904	6.71	5.471	5.51	4.3	4.56	4.21
Magnesium, Mg (mg/l)	mg/L	**<30**	**NS**	**40.626**	**42.8**	**45.6**	**46**	**47.1**	**49.1**	**47.003**	**46.275**	**42.8**	**45.713**	**46.8**	**43.3**	**44.3**	**45.8**
Sodium, Na	mg/L	**<100**	**<200**	38.881	39.4	42.4	47.6	53.5	72.5	51.953	47.438	45.3	35.391	38.6	32.9	35.3	32.2
Nitrate, NO_2+NO_3	mg/L	**<26.6**	**<48.7**	1.118	1.204	2.769	1.621	0.929	1.41	0.02	0.869	2.644	2.106	1.873	1.387	1.539	1.005
pH at 22 °C	pH units	**6-9**	**5-9.7**	8.16	8.56	8.66	8.46	8.39	8.57	8.48	8.76	8.59	8.393	8.17	8.32	8.39	8.3
Sulphate, SO_4	mg/L	**<200**	**<500**	87.424	96.6	106.6	96.9	102.2	121.9	113.011	109.711	115	111.889	130.4	116	113.3	115.9
Ammonium, NH_4	mg/L	**<1.0**	**<1.5**	0.02	0.02	0.02	0.02	0.059	0.02	0.02	0.104	0.059	0.091	0.125	0.041	0.02	0.127
Bicarbonate as $CaCO_3$	mg/L	**NS**	**NS**	60.18	66.37	66.25	65.51	68.56	75.03	71.32	67.36	66.37	72.47	72.22	65.76	69.05	72.59

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	07/06/1999	14/06/1999	21/06/1999	28/06/1999	02/07/1999	05/07/1999	12/07/1999	19/07/1999	26/07/1999	27/07/1999	02/08/1999	09/08/1999	16/08/1999	23/08/1999
Calcium, Ca	mg/L	<32	NS	60.4	62.3	57.3	58.8	59.9	58.9	60.7	61.5	60.5	60.3	60.4	66.1	57.2	66.6
Chloride, Cl	mg/L	<100	<300	35.7	38.5	39.3	39.5	37.5	43	39	36	35.5	39.4	36.8	56	56.9	58.6
Conductivity mS/m @ 25 °C	mS/m	<70	<170	76.3	79	77.4	77.6	75.3	78.5	78.2	77.9	78.5	80.8	79.4	88.2	88.9	91.7
Fluoride, F	mg/L	1	1.5	0.21	0.22	0.19	0.19	0.18	0.25	0.19	0.2	0.18	0.19	0.17	0.21	0.21	0.22
Potassium, K	mg/L	<50	NS	3.99	4.54	3.93	3.97	3.99	3.59	3.87	4.22	3.67	4.18	3.66	5.16	6.03	7.02
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.6	45.7	43.2	46.1	42.2	46.7	47.4	48.5	51.2	50.3	52.4	52.6	49.1	52.4
Sodium, Na	mg/L	<100	<200	31.9	36.2	32.5	33.7	33.9	34.4	33.9	30.2	33.7	37.7	33.5	49.2	50.5	50
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.687	1.082	0.792	1.067	0.584	0.671	0.716	0.486	0.94	1.24	1.31	1.857	3.219	3.309
pH at 22 °C	pH units	6-9	5-9.7	8.29	8.39	8.29	8.33	8.45	8.4	8.34	8.79	8.41	8.41	8.34	8.82	8.29	8.34
Sulphate, SO_4	mg/L	<200	<500	116.5	119.7	117.8	113.9	113.3	117.7	116.1	132.4	118.9	118.7	126.4	122.4	124.8	134.4
Ammonium, NH_4	mg/L	<1.0	<1.5	0.05	0.057	0.02	0.059	0.043	0.02	0.11	0.047	0.041	0.083	0.195	0.159	0.591	0.122
Bicarbonate as $CaCO_3$	mg/L	NS	NS	73.69	76.01	69.91	71.74	73.08	71.86	74.05	75.03	73.81	73.57	73.69	80.64	69.78	81.25

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	30/08/1999	06/09/1999	13/09/1999	20/09/1999	21/09/1999	27/09/1999	04/10/1999	11/10/1999	18/10/1999	25/10/1999	28/10/1999	01/11/1999	15/11/1999	22/11/1999
Calcium, Ca	mg/L	<32	NS	54.9	63.3	63.2	62.028	62.4	63.121	57.835	53.423	58.747	69.79	66.851	68.19	70.816	48.385
Chloride, Cl	mg/L	<100	<300	43.4	53.4	43.8	55.245	49.8	59.255	49.278	54.856	39.337	56.154	61.038	63.598	71.721	29.271
Conductivity mS/m @ 25 °C	mS/m	<70	<170	82.4	90.7	85.7	87.1	86.8	94	86	88.3	80.6	95.3	97.3	99.1	104.4	71
Fluoride, F	mg/L	1	1.5	0.19	0.23	0.22	0.219	0.24	0.244	0.225	0.216	0.204	0.239	0.215	0.199	0.25	0.178
Potassium, K	mg/L	<50	NS	5.39	7.46	5.49	6.403	5.79	8.034	7.214	8.209	5.873	8.49	8.999	8.826	10.95	3.106
Magnesium, Mg (mg/l)	mg/L	<30	NS	51.3	56.2	52.2	53.328	52.2	52.97	51.895	51.813	52.319	58.302	53.89	57.093	58.737	48.76
Sodium, Na	mg/L	<100	<200	42	48.3	42.2	49.94	45.9	54.708	47.592	52.213	40.56	52.698	54.571	52.727	63.227	28.424
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	1.704	3.026	1.427	1.744	1.386	1.171	1.365	1.311	0.079	0.219	0.249	0.02	0.085	0.08
pH at 22 °C	pH units	6-9	5-9.7	8.56	8.31	8.34	8.383	8.4	8.168	7.949	8.243	8.398	8.417	7.844	8.084	8.142	8.451
Sulphate, SO_4	mg/L	<200	<500	128.9	136	122.3	121.362	126.1	121.79	127.39	121.43	115.005	117.558	118.821	101.401	107.432	113.937
Ammonium, NH_4	mg/L	<1.0	<1.5	0.048	0.966	0.213	0.097	0.082	0.258	0.02	0.126	0.067	0.467	2.407	3.24	0.394	0.064
Bicarbonate as $CaCO_3$	mg/L	NS	NS	66.98	77.23	77.10	75.67	76.13	77.01	70.56	65.18	71.67	85.14	81.56	83.19	86.40	59.03

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	22/11/1999	29/11/1999	06/12/1999	13/12/1999	20/12/1999	29/12/1999	01/01/2000	10/01/2000	17/01/2000	25/01/2000	27/01/2000	31/01/2000	07/02/2000	21/02/2000
Calcium, Ca	mg/L	<32	NS	**47.058**	**37.5**	**67.181**	**53.033**	**49.339**	22.735	**40.097**	**53.4**	**50.055**	**51.583**	**51.867**	**46.8**	**50.804**	**37.497**
Chloride, Cl	mg/L	<100	<300	28.09	28.576	62.577	55.851	46.322	19.403	33.541	34.19	36.303	43.627	39.752	37.452	51.825	27.813
Conductivity mS/m @ 25 °C	mS/m	<70	<170	**72**	67.9	**95**	**87.8**	**81.8**	36.1	61.4	**73.5**	**71**	**78.3**	**74.1**	69.4	**74.1**	56.8
Fluoride, F	mg/L	1	1.5	0.232	0.212	0.25	0.221	0.203	0.458	0.297	0.222	0.237	0.246	0.202	0.238	0.27	0.252
Potassium, K	mg/L	<50	NS	3.001	2.147	8.318	7.89	6.943	5.754	6.935	4.946	4.283	4.494	4.26	4.95	4.673	5.599
Magnesium, Mg (mg/l)	mg/L	<30	NS	**44.477**	**45.747**	**56.694**	**51.173**	**48.306**	15.673	**30.007**	**44.868**	**44.234**	**43.622**	**41.387**	**37.231**	**41.429**	**30.128**
Sodium, Na	mg/L	<100	<200	27.739	26.043	61.902	47.375	42.481	18.145	31.221	31.657	33.163	36.013	35.338	33.959	44.074	27.592
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.089	0.02	0.052	0.546	0.582	0.734	1.916	1.158	0.321	0.365	0.686	1.105	1.203	0.02
pH at 22 °C	pH units	6-9	5-9.7	8.209	8.344	8.408	8.216	7.793	7.932	7.599	8.301	8.148	8.132	8.311	8.033	8.326	8.154
Sulphate, SO_4	mg/L	<200	<500	111.182	112.727	124.357	101.475	105.038	41.932	90.847	109.066	121.154	102.96	115.979	95.472	106.002	68.342
Ammonium, NH_4	mg/L	<1.0	<1.5	0.072	0.119	**1.291**	**5.926**	0.02	0.457	0.702	0.02	0.02	0.02	0.02	0.02	0.11	0.051
Bicarbonate as $CaCO_3$	mg/L	NS	NS	57.41	45.75	81.96	64.70	60.19	27.74	48.92	65.15	61.07	62.93	63.28	57.10	61.98	45.75

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	28/02/2000	06/03/2000	13/03/2000	20/03/2000	27/03/2000	03/04/2000	10/04/2000	17/04/2000	20/04/2000	02/05/2000	09/05/2000	15/05/2000	23/05/2000	29/05/2000
Calcium, Ca	mg/L	<32	NS	**40.228**	27.195	**37.882**	**40.343**	**88.766**	27.19	**43.082**	**44.925**	**39.665**	**50.964**	**42.635**	**51.613**	**52.94**	**52.417**
Chloride, Cl	mg/L	<100	<300	21.225	19.976	22.636	24.799	64.854	19.455	20.27	19.64	21.568	22.477	28.647	24.717	24.738	25.742
Conductivity mS/m @ 25 °C	mS/m	<70	<170	53	38.7	51.1	53.8	**109.3**	41.7	56	54.4	53.8	58.3	55.1	60.3	62.4	63.7
Fluoride, F	mg/L	1	1.5	0.205	0.808	0.293	0.389	0.214	0.298	0.213	0.205	0.219	0.209	0.251	0.195	0.186	0.215
Potassium, K	mg/L	<50	NS	4.128	5.716	4.515	4.706	9.214	4.837	3.886	3.843	4.031	3.872	4.489	3.602	3.682	3.872
Magnesium, Mg (mg/l)	mg/L	<30	NS	27.275	16.908	25.646	26.972	**49.302**	17.968	27.486	28.177	28.095	**31.999**	26.718	**33.955**	**35.445**	**36.771**
Sodium, Na	mg/L	<100	<200	21.226	16.213	23.477	24.578	71.565	20.8	20.64	20.27	20.186	21.279	25.067	24.984	25.003	23.584
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.084	0.164	0.123	0.382	1.48	0.052	0.3	0.438	0.427	0.713	0.207	0.538	0.686	0.904
pH at 22 °C	pH units	6-9	5-9.7	8.462	7.944	8.316	8.211	7.686	8.141	8.185	8.126	8.743	8.313	8.359	8.242	8.243	8.595
Sulphate, SO_4	mg/L	<200	<500	45.441	36.035	43.18	50.541	**229.709**	43.995	51.156	53.175	54.447	62.443	67.405	62.511	69.388	69.557
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.02	0.057	0.086	0.02	0.071	0.073	0.02	0.02	0.02	0.048	0.109	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	49.08	33.18	46.22	49.22	108.29	33.17	52.56	54.81	48.39	62.18	52.01	62.97	64.59	63.95

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	05/06/2000	12/06/2000	19/06/2000	03/07/2000	10/07/2000	17/07/2000	24/07/2000	31/07/2000	07/08/2000	14/08/2000	21/08/2000	29/08/2000	30/08/2000	04/09/2000
Calcium, Ca	mg/L	<32	NS	**57.756**	**54.346**	**55.353**	**52.496**	**58.252**	**57.632**	**57.925**	**57.647**	**57.547**	**60.358**	**60.376**	**62.653**	**59.526**	**60.374**
Chloride, Cl	mg/L	<100	<300	28.615	23.913	28.257	25.886	28.57	29.262	30.111	30.489	32.68	28.26	28.466	32.238	31.318	36.091
Conductivity mS/m @ 25 °C	mS/m	<70	<170	67.2	66.3	66.9	67.9	68.9	**70.5**	**71.7**	**71.5**	**72.7**	**72.5**	**73.1**	**74.3**	**74.7**	**78**
Fluoride, F	mg/L	1	1.5	0.198	0.206	0.215	0.2	0.194	0.209	0.248	0.281	0.177	0.178	0.21	0.214	0.184	0.188
Potassium, K	mg/L	<50	NS	3.898	4.247	4.009	4.368	4.748	4.108	4.314	3.937	3.789	4.112	4.37	4.567	5.149	5.515
Magnesium, Mg (mg/l)	mg/L	<30	NS	**35.664**	**37.795**	**38.828**	**36.724**	**35.464**	**38.85**	**40.03**	**41.507**	**43.471**	**44.105**	**43.844**	**46.727**	**43.832**	**44.515**
Sodium, Na	mg/L	<100	<200	26.472	24.548	27.153	28.659	29.306	30.391	29.699	27.941	26.472	29.001	27.352	29.832	29.277	32.285
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.955	0.62	0.826	0.574	0.761	0.918	0.96	0.834	1.088	0.922	1.001	1.089	1.119	1.334
pH at 22 °C	pH units	6-9	5-9.7	8.327	8.397	8.525	8.318	8.293	8.29	8.276	8.483	8.283	8.361	8.325	8.38	8.249	7.995
Sulphate, SO_4	mg/L	<200	<500	73.979	75.42	73.288	75.177	86.886	83.596	88.075	94.695	84.55	94.366	94.225	97.384	101.636	95.476
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.02	0.02	0.02	0.02	0.143	0.02	0.02	0.046	0.074	0.358	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	70.46	66.30	67.53	64.05	71.07	70.31	70.67	70.33	70.21	73.64	73.66	76.44	72.62	73.66

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	11/09/2000	18/09/2000	19/09/2000	26/09/2000	09/10/2000	16/10/2000	18/10/2000	23/10/2000	30/10/2000	06/11/2000	20/11/2000	21/11/2000	27/11/2000	04/12/2000
Calcium, Ca	mg/L	<32	NS	**62.82**	**64.277**	**64.633**	**60.624**	**57.006**	**61.065**	**62.67**	**55.876**	**68.144**	**55.458**	**59.05**	**56.41**	**55.087**	**58.628**
Chloride, Cl	mg/L	<100	<300	31.967	37.201	46.357	37.998	34.837	39.099	33.522	35.245	42.141	32.156	36.147	34.056	33.178	29.17
Conductivity mS/m @ 25 °C	mS/m	<70	<170	**74.9**	**78.9**	**82.6**	**76.1**	**73.2**	**75.2**	**77.3**	**70.7**	**74.6**	**72.8**	**73.4**	**73.5**	**71.3**	**71.4**
Fluoride, F	mg/L	1	1.5	0.185	0.198	0.207	0.415	0.255	0.415	0.311	0.289	0.364	0.265	0.246	0.238	0.226	0.186
Potassium, K	mg/L	<50	NS	4.026	4.784	6.841	5.102	4.924	4.902	5.317	6.933	5.048	4.474	4.867	5.067	4.249	3.696
Magnesium, Mg (mg/l)	mg/L	<30	NS	**41.099**	**44.007**	**47.258**	**44.479**	**41.39**	**45.871**	**44.667**	**38.169**	**43.124**	**41.501**	**40.7**	**39.683**	**42.603**	**43.397**
Sodium, Na	mg/L	<100	<200	28.42	32.335	39.985	33.409	31.722	36.656	32.336	33.738	35.768	31.916	33.222	30.342	32.657	30.534
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.763	1.053	1.458	0.754	1.359	1.18	0.972	1.179	0.534	0.429	1.376	1.355	0.603	0.635
pH at 22 °C	pH units	6-9	5-9.7	8.238	8.303	8.218	8.427	8.289	8.199	8.171	8.188	8.335	8.109	8.755	8.191	8.098	8.146
Sulphate, SO_4	mg/L	<200	<500	103.046	101.6	106.3	108.633	94.393	101.789	107.083	112.15	111.395	100.717	103.628	99.689	103.197	102.733
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.088	0.857	0.02	0.02	0.02	0.02	0.254	0.046	0.02	0.02	0.02	0.02	0.042
Bicarbonate as $CaCO_3$	mg/L	NS	NS	76.64	78.42	78.85	73.96	69.55	74.50	76.46	68.17	83.14	67.66	72.04	68.82	67.21	71.53

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	11/12/2000	12/12/2000	18/12/2000	27/12/2000	02/01/2001	08/01/2001	15/01/2001	22/01/2001	24/01/2001	29/01/2001	05/02/2001	12/02/2001	19/02/2001	26/02/2001
Calcium, Ca	mg/L	<32	NS	54.942	56.494	54.346	53.504	52.266	54.974	55.566	60.555	55.017	55.292	55.271	54.783	58.471	59.128
Chloride, Cl	mg/L	<100	<300	34.623	37.185	35.349	29.522	30.619	28.626	39.824	55.406	52.355	51.8	52.778	62.814	35.61	46.211
Conductivity mS/m @ 25 °C	mS/m	<70	<170	71.2	72	72.6	67.5	68.6	69.8	75.1	87.4	81.6	80.8	80	84.1	75.5	76.8
Fluoride, F	mg/L	1	1.5	0.203	0.225	0.208	0.279	0.232	0.197	0.258	0.241	0.227	0.24	0.299	0.336	0.233	0.845
Potassium, K	mg/L	<50	NS	4.572	4.326	3.687	3.214	3.166	3.065	5.061	7.258	8.78	9.631	7.624	8.307	6.271	9.048
Magnesium, Mg (mg/l)	mg/L	<30	NS	40.241	41.004	43.036	40.692	41.36	42.915	43.536	47.717	48.87	48.262	43.945	44.858	45.153	41.716
Sodium, Na	mg/L	<100	<200	32.894	33.999	33.493	28.237	28.682	32.501	37.159	50.587	47.919	46.991	45.373	51.389	38.704	39.875
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.733	1.023	0.793	0.439	0.422	0.533	0.569	0.158	0.02	1.107	0.02	0.02	0.164	0.02
pH at 22 °C	pH units	6-9	5-9.7	8.165	8.156	8.275	8.236	8.274	8.386	8.423	8.252	8.191	8.67	8.39	8.422	8.296	8.354
Sulphate, SO_4	mg/L	<200	<500	105.907	106.147	101.864	93.994	91.642	85.211	93.532	92.545	100.409	114.999	99.158	88.366	121.581	153.818
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.02	0.02	0.02	0.02	0.043	0.02	0.02	0.071	0.02	0.064	0.086	0.12
Bicarbonate as $CaCO_3$	mg/L	NS	NS	67.03	68.92	66.30	65.27	63.76	67.07	67.79	73.88	67.12	67.46	67.43	66.84	71.33	72.14

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	05/03/2001	12/03/2001	14/03/2001	19/03/2001	26/03/2001	02/04/2001	09/04/2001	16/04/2001	30/04/2001	07/05/2001	09/05/2001	14/05/2001	21/05/2001	28/05/2001
Calcium, Ca	mg/L	<32	NS	56.7	57.453	56.081	52.261	42.358	54.362	54.731	53.404	55.183	50.169	55.617	50.355	52.498	60.281
Chloride, Cl	mg/L	<100	<300	32.031	33.137	41.286	35.8	33.177	29.765	31.254	30.18	33.7	35.086	37.726	35.926	34.434	32.198
Conductivity mS/m @ 25 °C	mS/m	<70	<170	75.2	74.2	76.9	74.2	59.8	71.2	70.1	69.4	72.8	71	71.1	71.4	72.2	74.4
Fluoride, F	mg/L	1	1.5	0.374	0.253	0.484	0.304	0.447	0.238	0.239	0.213	0.217	0.362	0.252	0.218	0.207	0.205
Potassium, K	mg/L	<50	NS	5.294	4.741	5.504	5.279	8.036	4.152	4.079	3.668	4.623	4.108	3.603	3.782	3.787	5.356
Magnesium, Mg (mg/l)	mg/L	<30	NS	42.641	46.881	41.889	44.019	29.23	43.09	41.866	44.748	42.384	42.951	40.646	43.078	44.478	50.187
Sodium, Na	mg/L	<100	<200	30.374	31.258	36.511	32.754	29.397	30.231	28.611	28.925	32.214	32.813	32.576	29.816	29.162	33.522
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.868	1.072	2.09	1.25	1.477	0.799	0.951	0.72	1.36	0.685	0.484	0.716	0.79	0.981
pH at 22 °C	pH units	6-9	5-9.7	8.187	8.378	8.284	8.515	7.461	8.249	8.277	8.175	8.16	8.209	8.18	8.198	8.227	8.255
Sulphate, SO_4	mg/L	<200	<500	125.626	114.996	112.447	112.478	97.896	92.2	108.753	96.875	86.543	96.794	98.657	94.933	93.79	107.534
Ammonium, NH_4	mg/L	<1.0	<1.5	0.053	0.02	0.054	0.02	0.02	0.02	0.02	0.02	0.02	0.066	0.02	0.02	0.02	0.125
Bicarbonate as $CaCO_3$	mg/L	NS	NS	69.17	70.09	68.42	63.76	51.68	66.32	66.77	65.15	67.32	61.21	67.85	61.43	64.05	73.54

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	04/06/2001	11/06/2001	18/06/2001	25/06/2001	02/07/2001	03/07/2001	09/07/2001	17/07/2001	23/07/2001	30/07/2001	06/08/2001	13/08/2001	20/08/2001	27/08/2001
Calcium, Ca	mg/L	<32	NS	57.423	58.222	60.366	60.16	56.576	58	56.697	64.839	52.095	65.564	62.805	67.345	62.034	66.527
Chloride, Cl	mg/L	<100	<300	31.567	32.805	30.21	33.486	31.71	28	32.165	35.065	33.28	35.499	31.202	31.535	31.324	34.676
Conductivity mS/m @ 25 °C	mS/m	<70	<170	73.1	72.2	73.3	73.9	72	76	72.8	76.2	76.3	76.3	77	76.1	77.4	76.4
Fluoride, F	mg/L	1	1.5	0.204	0.193	0.184	0.19	0.198	0.2	0.18	0.193	0.184	0.225	0.189	0.177	0.197	0.221
Potassium, K	mg/L	<50	NS	4.538	4.461	4.154	4.123	4.043	4.5	3.9	4.012	4.035	4.791	4.409	4.044	4.181	4.323
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.739	50.109	46.136	44.549	43.802	40.3	46.386	44.446	43.438	45.242	46.309	45.621	46.878	44.644
Sodium, Na	mg/L	<100	<200	33.434	33.275	33.116	32.208	26.481	33.8	28.387	26.69	34.068	33.371	31.651	29.839	30.928	27.953
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.952	0.55	0.987	0.788	1.001	0.9	1.247	1.629	1.812	1.909	1.678	1.651	1.577	1.061
pH at 22 °C	pH units	6-9	5-9.7	8.207	8.167	8.541	8.429	8.298	8.4	8.711	8.251	8.289	8.5	8.278	8.304	8.263	8.45
Sulphate, SO_4	mg/L	<200	<500	104.962	103.534	111.008	118.502	105.395	105	109.14	104.039	92.106	105.608	99.362	107.822	112.538	105.702
Ammonium, NH_4	mg/L	<1.0	<1.5	0.058	0.085	0.02	0.073	0.063	0.4	0.056	0.33	0.36	0.077	0.058	0.044	0.121	0.049
Bicarbonate as $CaCO_3$	mg/L	NS	NS	70.06	71.03	73.65	73.40	69.02	70.76	69.17	79.10	63.56	79.99	76.62	82.16	75.68	81.16

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	31/08/2001	03/09/2001	10/09/2001	17/09/2001	25/09/2001	27/09/2001	01/10/2001	08/10/2001	15/10/2001	22/10/2001	29/10/2001	31/10/2001	05/11/2001	12/11/2001
Calcium, Ca	mg/L	<32	NS	39	63.177	67.524	62.998	64.142	62	61.254	58.154	66.85	63.418	60.29	51	52.676	54.971
Chloride, Cl	mg/L	<100	<300	33	39.812	41.345	48.339	42.217	33	34.976	37.543	55.801	46.866	36.947	44	93.888	38.057
Conductivity mS/m @ 25 °C	mS/m	<70	<170	77	80.9	78.9	75.8	79.7	80	76.4	78.9	94.3	84	76	77	76.6	72.1
Fluoride, F	mg/L	1	1.5	0.1	0.197	0.178	0.207	0.18	0.7	0.18	0.193	0.192	0.193	0.593	0.3	0.381	0.405
Potassium, K	mg/L	<50	NS	5.3	5.551	7.161	4.49	6.065	6.1	5.191	5.791	10.807	8.324	6.102	5	6.003	5.052
Magnesium, Mg (mg/l)	mg/L	<30	NS	40.1	45.617	47.47	47.254	45.71	40.7	47.131	47.453	49.335	43.945	44.662	38.5	37.039	40.036
Sodium, Na	mg/L	<100	<200	40.1	38.267	37.37	39.736	34.137	44.2	33.914	36.568	51.381	42.834	27.709	46	40.259	32.341
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	1.9	1.752	2.794	1.466	2.438	3	1.332	1.68	1.96	1.584	1.538	0.8	0.082	0.963
pH at 22 °C	pH units	6-9	5-9.7	8.1	8.222	8.591	8.997	8.13	7.9	8.546	8.561	8.264	8.339	8.296	7.8	8.158	8.091
Sulphate, SO_4	mg/L	<200	<500	105	99.52	105.578	101.972	105.646	109	119.493	101.771	101.738	96.71	108.172	133	26.568	101.793
Ammonium, NH_4	mg/L	<1.0	<1.5	0.3	2.282	0.938	0.119	0.107	0.2	0.133	0.089	4.759	3.96	1.316	0.05	0.05	0.128
Bicarbonate as $CaCO_3$	mg/L	NS	NS	47.58	77.08	82.38	76.86	78.25	75.64	74.73	70.95	81.56	77.37	73.55	62.22	64.26	67.06

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	21/11/2001	22/11/2001	26/11/2001	03/12/2001	10/12/2001	13/12/2001	20/12/2001	28/12/2001	04/01/2002	09/01/2002	14/01/2002	23/01/2002	30/01/2002	30/01/2002
Calcium, Ca	mg/L	<32	NS	35.758	40	47.104	45.48	40.709	40	45.29	30.407	46.622	45.592	49.897	56.643	37.911	47.6
Chloride, Cl	mg/L	<100	<300	36.183	51	33.636	34.922	25.253	31	25.678	23.459	22.546	30.99	34.026	43.23	30.562	49
Conductivity mS/m @ 25 °C	mS/m	<70	<170	55.5	62	65.2	63.1	58.4	59	59.1	45.4	59.9	65.8	64.4	70.4	58.2	62
Fluoride, F	mg/L	1	1.5	0.5	0.6	0.311	0.44	0.274	0.2	0.265	0.452	0.249	0.245	0.46	0.383	0.277	0.4
Potassium, K	mg/L	<50	NS	8.993	7.3	4.336	5.401	4.488	5.1	4.044	5.745	3.942	4.315	5.788	6.805	8.166	7.3
Magnesium, Mg (mg/l)	mg/L	<30	NS	26.2	29.8	35.83	33.274	33.008	29.3	34.378	21.439	33.291	37.62	36.062	39.327	29.036	34.6
Sodium, Na	mg/L	<100	<200	30.824	45.7	31.261	34.862	26.033	32.4	23.045	20.955	22.399	26.451	31.969	37.11	30.52	36.6
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.149	0.1	0.334	0.414	0.02	0.1	0.146	0.456	0.375	0.618	1.082	1.606	0.748	2.4
pH at 22 °C	pH units	6-9	5-9.7	8.068	7.7	8.354	8.191	8.258	8.7	8.25	8.019	8.138	8.288	8.117	8.272	7.922	7.9
Sulphate, SO_4	mg/L	<200	<500	82.783	89	68.394	82.669	58.88	62	61.577	47.043	52.825	60.72	69.366	70.573	123.145	88
Ammonium, NH_4	mg/L	<1.0	<1.5	0.089	0.05	0.076	0.041	0.043	0.05	0.043	0.02	0.02	0.044	0.02	0.099	0.38	1
Bicarbonate as $CaCO_3$	mg/L	NS	NS	43.62	48.80	57.47	55.49	49.66	48.80	55.25	37.10	56.88	55.62	60.87	69.10	46.25	58.07

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	06/02/2002	13/02/2002	20/02/2002	26/02/2002	27/02/2002	05/03/2002	12/03/2002	19/03/2002	26/03/2002	03/04/2002	08/04/2002	16/04/2002	23/04/2002	23/04/2002
Calcium, Ca	mg/L	<32	NS	34.012	33.855	34.246	43.167	42.6	51.872	44.791	52.427	51.473	56.21	55.377	55.629	57.256	55.4
Chloride, Cl	mg/L	<100	<300	23.368	21.218	24.859	25.591	66	27.424	26.152	30.761	33.683	36.613	38.639	34.716	38.045	46
Conductivity mS/m @ 25 °C	mS/m	<70	<170	49.7	46.5	47	58.8	56	63.3	60	64.7	70.5	70.6	71.9	70.1	73.6	70
Fluoride, F	mg/L	1	1.5	0.333	0.285	0.884	0.286	0.3	0.239	0.24	0.232	0.219	0.221	0.32	0.244	0.242	0.6
Potassium, K	mg/L	<50	NS	5.189	5.113	4.723	4.113	5	3.878	4.309	4.173	4.742	4.333	5.124	5.347	4.07	5.2
Magnesium, Mg (mg/l)	mg/L	<30	NS	24.831	22.132	23.53	32.638	30.7	37.888	29.551	37.714	43.496	44.237	42.023	40.077	48.161	42.1
Sodium, Na	mg/L	<100	<200	26.612	21.698	23.407	24.81	34.3	21.356	25.174	29.219	28.546	28.11	31.857	28.345	32.523	36.5
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.052	0.043	0.375	0.395	0.9	0.479	0.637	1.242	1.581	1.632	1.72	1.929	2.345	3.3
pH at 22 °C	pH units	6-9	5-9.7	8.05	8.126	8.08	8.186	8.2	8.203	8.255	8.208	8.256	8.234	8.075	8.067	8.36	7.9
Sulphate, SO_4	mg/L	<200	<500	49.981	45.799	52.745	62.719	72	67.054	68.215	77.156	70.131	82.466	91.138	85.647	90.499	86
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.047	0.054	0.02	0.05	0.02	0.068	0.058	0.02	0.143	0.41	0.603	0.05	0.05
Bicarbonate as $CaCO_3$	mg/L	NS	NS	41.49	41.30	41.78	52.66	51.97	63.28	54.65	63.96	62.80	68.58	67.56	67.87	69.85	67.59

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	24/04/2002	30/04/2002	07/05/2002	14/05/2002	21/05/2002	28/05/2002	30/05/2002	04/06/2002	10/06/2002	19/06/2002	25/06/2002	03/07/2002	09/07/2002	16/07/2002
Calcium, Ca	mg/L	<32	NS	55.4	61.779	56.592	55.152	56.99	55.395	71.2	59.692	52.689	57.029	58.05	58.614	57.532	62.093
Chloride, Cl	mg/L	<100	<300	46	45.884	38.05	30.498	35.373	36.276	40	48.092	34.447	36.83	34.093	35.31	33.45	33.213
Conductivity mS/m @ 25 °C	mS/m	<70	<170	70	76.1	72.8	69.6	70.6	71.1	73	76.4	67.9	67.8	68.3	72.3	72.7	69.6
Fluoride, F	mg/L	1	1.5	0.6	0.268	0.248	0.19	0.166	0.294	0.05	0.378	0.225	0.228	0.205	0.211	0.178	0.193
Potassium, K	mg/L	<50	NS	5.2	5.12	5.942	4.7	5.037	4.741	5	10.551	4.979	4.19	4.055	4.458	4.096	4.735
Magnesium, Mg (mg/l)	mg/L	<30	NS	42.1	44.607	44.431	45.214	45.517	45.473	42.2	42.671	39.101	40.697	41.583	45.709	47.637	45.816
Sodium, Na	mg/L	<100	<200	36.5	38.712	32.365	29.957	32.271	32.555	37.8	38.631	29.833	32.263	30.896	33.105	31.158	31.773
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	3.3	2.63	0.089	1.966	2.14	1.985	1.9	1.459	0.87	1.093	1.15	1.481	1.392	1.46
pH at 22 °C	pH units	6-9	5-9.7	7.9	8.263	8.301	8.357	8.134	8.118	8.3	8.095	8.295	8.451	8.391	8.399	8.3	8.348
Sulphate, SO_4	mg/L	<200	<500	86	89.616	90.638	90.861	91.931	93.031	119	159.327	114.759	93.492	86.749	95.161	98.647	110.25
Ammonium, NH_4	mg/L	<1.0	<1.5	0.05	0.02	0.257	0.02	0.042	0.02	0.2	0.286	0.061	0.02	0.02	0.078	0.097	0.056
Bicarbonate as $CaCO_3$	mg/L	NS	NS	67.59	75.37	69.04	67.29	69.53	67.58	86.86	72.82	64.28	69.58	70.82	71.51	70.19	75.75

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	23/07/2002	30/07/2002	06/08/2002	13/08/2002	21/08/2002	22/08/2002	27/08/2002	03/09/2002	10/09/2002	17/09/2002	17/09/2002	25/09/2002	01/10/2002	08/10/2002
Calcium, Ca	mg/L	<32	NS	58.743	59.874	60.862	59.491	68.489	76	65.567	66.332	53.543	54.6	41.598	58.394	56.145	63.206
Chloride, Cl	mg/L	<100	<300	36.301	30.381	36.901	30.937	88.884	43	47.409	41.232	30.776	48	24.819	43.115	39.998	46.727
Conductivity mS/m @ 25 °C	mS/m	<70	<170	70.3	71.3	73.6	71.9	94.1	58	77.4	84.1	66.3	77	54.2	79.5	77.3	84.9
Fluoride, F	mg/L	1	1.5	0.25	0.248	0.204	0.234	0.311	0.3	0.265	0.245	0.204	0.2	0.215	0.193	0.196	0.186
Potassium, K	mg/L	<50	NS	4.265	3.372	4.314	3.865	8.166	5.2	5.745	4.746	3.419	4.7	2.843	5.22	5.5	6.38
Magnesium, Mg (mg/l)	mg/L	<30	NS	45.346	39.662	49.128	45.154	39.084	38.6	47.072	45.568	39.234	41.9	30.624	47.827	44.722	46.273
Sodium, Na	mg/L	<100	<200	33.149	27.794	34.263	26.43	83.695	43	39.406	31.566	26.71	43.2	18.876	34.56	39.297	38.287
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	1.5	0.895	1.27	1.108	1.206	1.5	2.27	1.327	0.928	2	1.198	1.643	1.293	2.392
pH at 22 °C	pH units	6-9	5-9.7	8.139	8.343	8.305	8.309	8.086	7.6	8.052	8.076	8.482	8	8.349	8.354	8.493	8.226
Sulphate, SO_4	mg/L	<200	<500	97.04	100.073	94.233	97.917	222.895	119	92.166	91.68	84.091	112	66.804	102.356	100.526	101.18
Ammonium, NH_4	mg/L	<1.0	<1.5	0.085	0.057	0.118	0.062	0.219	0.05	0.405	0.103	0.074	0.05	0.062	0.124	0.087	0.142
Bicarbonate as $CaCO_3$	mg/L	NS	NS	71.67	73.05	74.25	72.58	83.56	92.72	79.99	80.93	65.32	66.61	50.75	71.24	68.50	77.11

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	15/10/2002	21/10/2002	28/10/2002	05/11/2002	11/11/2002	18/11/2002	25/11/2002	02/12/2002	09/12/2002	13/12/2002	16/12/2002	23/12/2002	30/12/2002	06/01/2003
Calcium, Ca	mg/L	<32	NS	60.785	55.612	60.545	59.288	53.469	56.058	48.837	57.922	58.964	45.5	51.532	52.914	56.426	54.009
Chloride, Cl	mg/L	<100	<300	41.036	34.292	42.984	40.264	36.051	42.166	34.553	48.111	69.101	47	42.612	36.245	39.29	36.713
Conductivity mS/m @ 25 °C	mS/m	<70	<170	77.6	77.4	78.4	73.3	71.7	78.8	74	82.5	96.6	72	74.5	72.7	72.7	74.7
Fluoride, F	mg/L	1	1.5	0.246	0.217	0.224	0.197	0.189	0.216	0.148	0.227	0.184	0.3	1.077	0.622	0.296	0.264
Potassium, K	mg/L	<50	NS	5.855	5.26	7.12	4.671	4.352	5.12	4.228	5.23	8.447	7.7	8.029	5.534	3.799	3.898
Magnesium, Mg (mg/l)	mg/L	<30	NS	43.961	45.557	46.644	44.685	45.687	46.2	44.68	48.137	49.172	39.7	35.242	38.542	49.189	49.765
Sodium, Na	mg/L	<100	<200	32.97	31.137	34.773	34.53	32.68	35.535	28.462	43.33	57.963	45.1	33.299	29.801	28.001	27.794
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	1.912	0.942	2.309	0.847	0.706	0.363	0.091	0.122	0.23	2.2	1.719	1.689	0.622	0.481
pH at 22 °C	pH units	6-9	5-9.7	8.26	8.263	8.091	8.237	8.375	8.52	8.439	8.408	8.213	7.3	8.056	8.208	8.297	8.347
Sulphate, SO_4	mg/L	<200	<500	101.188	106.722	98.456	112.782	103.065	105.289	97.608	95.704	113.006	157	145.693	116.812	112.116	101.765
Ammonium, NH_4	mg/L	<1.0	<1.5	0.15	0.043	0.02	0.052	0.088	0.085	0.11	0.02	0.153	0.05	0.496	0.057	0.02	0.072
Bicarbonate as $CaCO_3$	mg/L	NS	NS	74.16	67.85	73.86	72.33	65.23	68.39	59.58	70.66	71.94	55.51	62.87	64.56	68.84	65.89

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	13/01/2003	17/01/2003	20/01/2003	27/01/2003	03/02/2003	10/02/2003	17/02/2003	17/02/2003	24/02/2003	03/03/2003	10/03/2003	17/03/2003	24/03/2003	31/03/2003
Calcium, Ca	mg/L	<32	NS	47.042	49.8	55.257	49.527	51.307	54.631	37.5	46.217	41.674	53.074	51.696	54.973	39.74	52.394
Chloride, Cl	mg/L	<100	<300	37.572	50	37.774	47.805	42.692	60.471	43	46.256	45.55	51.248	40.556	54.672	38.437	40.254
Conductivity mS/m @ 25 °C	mS/m	<70	<170	65.5	68	71.9	75.5	80	86.5	65	75.4	67	78	75.2	81.7	65.5	74.4
Fluoride, F	mg/L	1	1.5	0.393	0.4	0.248	0.559	0.427	0.304	0.6	0.393	0.812	0.742	0.403	0.413	1.161	0.497
Potassium, K	mg/L	<50	NS	4.505	5.7	4.614	8.149	7.89	9.862	8.9	7.977	6.646	7.596	6.293	7.757	6.89	5.656
Magnesium, Mg (mg/l)	mg/L	<30	NS	39.16	36.4	46.946	42.506	39.458	49.52	31.9	39.49	34.628	46.948	47.506	48.031	38.686	48.48
Sodium, Na	mg/L	<100	<200	26.732	36	29.174	39.168	40.227	45.718	41.2	44.898	35.311	35.634	31.497	45.131	30.243	31.135
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	1.148	3.1	0.698	1.841	1.353	1.701	0.5	0.127	1.699	0.818	0.529	0.304	1.417	1.364
pH at 22 °C	pH units	6-9	5-9.7	8.112	8.2	8.217	8.111	8.189	8.184	7.9	8.126	8.104	8.158	8.099	8.049	8.077	8.159
Sulphate, SO_4	mg/L	<200	<500	97.991	97	110.96	91.905	97.666	88.696	72	86.598	97.442	108.472	109.28	109.433	110.163	111.612
Ammonium, NH_4	mg/L	<1.0	<1.5	0.097	0.05	0.064	0.02	0.041	0.081	0.05	0.02	0.097	0.02	0.075	0.073	0.065	0.044
Bicarbonate as $CaCO_3$	mg/L	NS	NS	57.39	60.76	67.41	60.42	62.59	66.65	45.75	56.38	50.84	64.75	63.07	67.07	48.48	63.92

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	07/04/2003	14/04/2003	17/04/2003	22/04/2003	29/04/2003	06/05/2003	12/05/2003	18/05/2003	19/05/2003	26/05/2003	02/06/2003	09/06/2003	17/06/2003	23/06/2003
Calcium, Ca	mg/L	<32	NS	48.245	51.501	57.072	51.331	54.413	56.969	58.294	51.008	51.381	53.34	56.944	58.734	58.752	56.662
Chloride, Cl	mg/L	<100	<300	48.212	61.311	51.045	55.425	45.176	53.444	50.436	53.065	41.773	41.382	45.769	38.916	34.827	34.191
Conductivity mS/m @ 25 °C	mS/m	<70	<170	77.5	81.8	81.2	80.7	72.5	83	82.2	79.4	76	77	82.7	80.8	75.4	74.2
Fluoride, F	mg/L	1	1.5	0.384	0.288	0.318	0.256	0.226	0.243	0.262	0.214	0.226	0.241	0.209	0.256	0.212	0.247
Potassium, K	mg/L	<50	NS	6.028	8.397	7.972	7.463	4.9	6.769	6.279	6.001	4.893	5.273	7.289	6.56	4.455	4.181
Magnesium, Mg (mg/l)	mg/L	<30	NS	49.739	50.226	52.162	50.02	48.031	49.586	50.229	49.453	49.498	48.099	50.98	50.155	50.367	46.412
Sodium, Na	mg/L	<100	<200	34.642	49.332	40.369	45.608	32.604	44.656	44.546	44.386	36.696	39.874	46.318	40.785	32.499	28.903
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	1.09	1.66	1.634	2.168	1.029	1.319	1.307	0.755	0.715	0.713	1.525	1.016	0.508	0.501
pH at 22 °C	pH units	6-9	5-9.7	8.221	8.328	8.114	8.187	8.181	8.217	8.246	8.32	8.256	8.273	8.155	8.212	8.221	8.328
Sulphate, SO_4	mg/L	<200	<500	105.416	114.417	114.332	113.938	115.599	122.499	123.579	114.829	126.35	110.589	116.436	134.171	119.77	123.412
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.157	0.047	0.077	0.062	0.02	0.02	0.043	0.02	0.053	0.02	0.02	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	58.86	62.83	69.63	62.62	66.38	69.50	71.12	62.23	62.68	65.07	69.47	71.66	71.68	69.13

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	30/06/2003	07/07/2003	14/07/2003	21/07/2003	28/07/2003	04/08/2003	11/08/2003	19/08/2003	25/08/2003	01/09/2003	08/09/2003	15/09/2003	22/09/2003	29/09/2003
Calcium, Ca	mg/L	<32	NS	61.455	52.194	58.034	58.63	59.237	60.435	59.462	57.408	57.158	50.367	58.528	59.669	53.829	63.35
Chloride, Cl	mg/L	<100	<300	33.966	32.159	28.647	39.976	39.775	41.531	43.405	43.608	39.721	33.492	61.045	41.809	54.505	53.605
Conductivity mS/m @ 25 °C	mS/m	<70	<170	73.7	72.3	75.7	77.2	76.9	81.2	80.9	81.4	78.7	76.4	89.4	80.1	79.8	87.5
Fluoride, F	mg/L	1	1.5	0.194	0.201	0.18	0.17	0.184	0.264	0.651	0.374	0.233	0.297	0.33	0.259	0.271	0.276
Potassium, K	mg/L	<50	NS	4.214	3.442	3.446	4.676	5.021	4.792	6.373	6.558	4.851	4.033	6.391	4.667	5.943	6.479
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.88	47.075	47.574	50.366	46.442	49.523	48.083	53.675	50.45	52.922	53.832	51.211	53.184	53.428
Sodium, Na	mg/L	<100	<200	30.275	25.105	23.349	33.067	32.522	28.996	36.65	40.384	32.95	29.582	41.214	32.891	41.907	36.35
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.696	0.143	0.02	0.604	0.898	0.577	1.548	1.953	0.92	0.02	0.37	0.402	1.417	0.02
pH at 22 °C	pH units	6-9	5-9.7	8.317	8.368	8.304	8.351	8.273	8.465	8.206	8.388	8.542	8.523	8.244	8.374	8.119	8.157
Sulphate, SO_4	mg/L	<200	<500	107.812	113.283	111.607	115.131	111.058	96.34	118.363	113.538	107.937	102.068	116.626	103.381	105.247	102.677
Ammonium, NH_4	mg/L	<1.0	<1.5	0.062	0.02	0.02	0.02	0.02	0.02	0.345	0.061	0.111	0.02	0.02	0.02	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	74.98	63.68	70.80	71.53	72.27	73.73	72.54	70.04	69.73	61.45	71.40	72.80	65.67	77.29

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	06/10/2003	13/10/2003	16/10/2003	20/10/2003	27/10/2003	03/11/2003	10/11/2003	17/11/2003	19/11/2003	24/11/2003	01/12/2003	04/12/2003	08/12/2003	15/12/2003
Calcium, Ca	mg/L	<32	NS	53.944	42.318	51.366	47.274	54.805	42.426	59.207	41.004	40.2	43.21	54.529	53.2	50.71	63.023
Chloride, Cl	mg/L	<100	<300	44.824	28.801	37.665	36.245	60.158	37.696	69.905	46.062	32	45.989	50.128	59	53.219	74.956
Conductivity mS/m @ 25 °C	mS/m	<70	<170	79.3	68.8	74.8	73.5	90.7	67.2	89.4	65.2	56	69.4	76.6	78	80.2	92.6
Fluoride, F	mg/L	1	1.5	0.256	0.183	0.219	0.238	0.27	0.294	0.45	0.326	0.4	0.828	0.71	0.7	0.455	0.469
Potassium, K	mg/L	<50	NS	6.161	3.125	4.732	4.172	9.934	8.364	11.191	9.546	8.4	7.974	8.142	9.1	7.462	10.354
Magnesium, Mg (mg/l)	mg/L	<30	NS	51.034	50.531	52.408	51.382	54.144	37.975	48.149	34.146	34.3	37.487	42.618	45.6	42.912	54.553
Sodium, Na	mg/L	<100	<200	43.538	26.075	35.056	32.498	58.807	34.944	62.665	39.778	40.1	36.044	49.469	51.8	42.023	55.554
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.051	0.02	0.042	0.02	0.055	0.055	0.055	0.737	1.6	0.055	0.121	0.2	0.135	0.055
pH at 22 °C	pH units	6-9	5-9.7	8.157	8.318	8.087	8.136	8.502	8.053	8.152	8.114	7.7	8.04	7.975	8.3	8.088	8.064
Sulphate, SO_4	mg/L	<200	<500	113.632	104.154	112.23	105.016	119.193	84.599	107.975	88.758	106	89.844	104.019	107	101.246	120.993
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.02	0.02	0.015	0.015	0.015	0.015	0.4	0.015	0.015	0.05	0.015	0.015
Bicarbonate as $CaCO_3$	mg/L	NS	NS	65.81	51.63	62.67	57.67	66.86	51.76	72.23	50.02	49.04	52.72	66.53	64.90	61.87	76.89

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	29/12/2003	05/01/2004	26/01/2004	30/01/2004	02/02/2004	17/02/2004	24/02/2004	01/03/2004	15/03/2004	19/03/2004	23/03/2004	29/03/2004	01/04/2004	05/04/2004
Calcium, Ca	mg/L	<32	NS	57.974	66.363	48.863	41.6	48.548	44.002	41.574	47.653	38.901	50.1	52.358	48.087	51.788	51.146
Chloride, Cl	mg/L	<100	<300	59.234	103.433	56.918	67	47.589	51.088	38.936	36.025	25.287	32	27.962	26.93	30.307	31.498
Conductivity mS/m @ 25 °C	mS/m	<70	<170	82.8	112.5	75.4	74	75.3	69.5	65.6	66.6	52.5	61	66.2	63.1	67.1	66.2
Fluoride, F	mg/L	1	1.5	0.449	0.415	0.401	0.7	0.608	0.388	0.503	0.934	0.387	0.4	0.54	0.363	0.376	0.284
Potassium, K	mg/L	<50	NS	10.433	14.52	9.867	10.1	10.035	11.39	6.276	9.371	6.556	5.6	5.046	4.929	5.286	4.893
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.457	57.978	40.187	41	40.271	36.839	36.051	38.704	27.622	27.5	39.386	39.384	40.128	40.033
Sodium, Na	mg/L	<100	<200	45.277	89.937	41.404	45.8	44.865	40.13	35.806	28.892	21.468	25.6	24.005	20.359	26.381	27.657
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.055	0.055	0.055	0.2	0.055	0.055	0.221	0.244	0.389	0.05	0.055	0.167	0.055	0.267
pH at 22 °C	pH units	6-9	5-9.7	8.102	8.184	8.126	7.9	7.862	7.893	8.005	8.12	7.849	8.2	8.06	7.894	7.863	8.075
Sulphate, SO_4	mg/L	<200	<500	117.278	136.058	120.518	159	128.73	114.432	108.202	102.447	60.003	80	84.197	79.631	75.666	80.572
Ammonium, NH_4	mg/L	<1.0	<1.5	0.047	0.015	0.015	0.05	0.015	0.015	0.138	0.015	0.015	0.05	0.015	0.015	0.015	0.015
Bicarbonate as $CaCO_3$	mg/L	NS	NS	70.73	80.96	59.61	50.75	59.23	53.68	50.72	58.14	47.46	61.12	63.88	58.67	63.18	62.40

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	*Unit*	DWA SAWQTV Drinking Water	SANS 241-1: 2011	11/04/2004	19/04/2004	26/04/2004	03/05/2004	10/05/2004	17/05/2004	24/05/2004	26/05/2004	01/06/2004	08/06/2004	15/06/2004	22/06/2004	29/06/2004	06/07/2004
Calcium, Ca	mg/L	<32	NS	52.916	56.507	54.953	54.536	60.445	59.684	65.01	59	61.861	62.303	64.833	59.745	61.231	61.912
Chloride, Cl	mg/L	<100	<300	32.291	33.479	36.169	42.311	36.07	36.915	37.661	46	44.949	33.17	45.202	40.507	39.981	36.364
Conductivity mS/m @ 25 °C	mS/m	<70	<170	71.9	67.2	72.4	76.3	73.5	78.1	77.1	80	80.1	77.7	80.6	78.8	79.5	76.2
Fluoride, F	mg/L	1	1.5	0.915	0.355	0.465	0.356	0.301	0.297	0.297	0.3	0.273	0.214	0.25	0.21	0.244	0.502
Potassium, K	mg/L	<50	NS	5.26	4.518	4.957	5.467	4.71	5.851	4.934	6.8	5.933	4.232	5.297	4.559	4.849	5.069
Magnesium, Mg (mg/l)	mg/L	<30	NS	40.155	45.809	46.001	46.821	47.477	49.457	49.408	38	47.461	46.449	47.747	46.228	48.68	49.705
Sodium, Na	mg/L	<100	<200	24.712	30.008	27.911	31.652	33.449	34.484	29.782	26.1	35.869	29.232	34.897	33.759	33.086	29.02
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.593	0.456	0.684	0.483	0.484	0.817	0.69	1	1.042	0.232	0.055	0.21	0.248	0.556
pH at 22 °C	pH units	6-9	5-9.7	8.124	8.098	8.059	8.184	8.293	8.164	8.374	7.9	8.382	8.292	7.8	8.293	8.354	8.032
Sulphate, SO_4	mg/L	<200	<500	90.449	96.554	93.031	94.163	101.507	105.865	109.863	120	107.577	109.651	114.312	109.329	106.178	108.807
Ammonium, NH_4	mg/L	<1.0	<1.5	0.015	0.033	0.015	0.015	0.061	0.037	0.062	0.05	0.015	0.015	0.015	0.032	0.041	0.015
Bicarbonate as $CaCO_3$	mg/L	NS	NS	64.56	68.94	67.04	66.53	73.74	72.81	79.31	71.98	75.47	76.01	79.10	72.89	74.70	75.53

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	*Unit*	DWA SAWQTV Drinking Water	SANS 241-1: 2011	13/07/2004	21/07/2004	28/07/2004	04/08/2004	12/08/2004	18/08/2004	25/08/2004	01/09/2004	08/09/2004	15/09/2004	22/09/2004	29/09/2004	01/10/2004	06/10/2004
Calcium, Ca	mg/L	<32	NS	66.233	61.295	51.823	56.898	56.556	60.156	61.182	63.997	66.439	63.576	63.494	60.543	56.226	62.972
Chloride, Cl	mg/L	<100	<300	36.428	38.361	40.131	43.362	41.333	37.461	43.463	47.347	36.44	50.004	53.103	49.287	52.857	52.48
Conductivity mS/m @ 25 °C	mS/m	<70	<170	78.5	79.8	79.7	81.8	82.5	81	83.2	82	78.7	80.6	88.4	85.7	87.3	88.9
Fluoride, F	mg/L	1	1.5	0.329	0.266	0.217	0.205	0.262	0.257	0.305	0.419	0.26	0.222	0.261	0.224	0.258	0.241
Potassium, K	mg/L	<50	NS	3.978	4.691	4.595	5.919	5.007	4.813	5.255	6.108	4.264	4.593	6.18	5.605	5.87	6.388
Magnesium, Mg (mg/l)	mg/L	<30	NS	44.796	46.92	51.756	51.276	49.381	47.155	48.599	48.206	48.135	50.172	52.028	51.026	54.2	52.601
Sodium, Na	mg/L	<100	<200	29.882	33.636	33.495	38.784	37.337	33.419	33.634	37.03	30.386	34.798	43.131	40.771	47.262	45.724
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.292	0.198	0.234	0.458	0.576	0.506	0.651	0.644	0.368	0.522	0.31	0.237	0.055	0.055
pH at 22 °C	pH units	6-9	5-9.7	8.369	8.307	8.409	8.313	8.291	8.32	8.035	8.058	8.153	8.193	8.252	8.285	8.353	8.182
Sulphate, SO_4	mg/L	<200	<500	102.686	105.418	105.708	123.943	117.977	108.061	101.978	107.375	106.671	109.166	112.245	112.549	123.789	111.611
Ammonium, NH_4	mg/L	<1.0	<1.5	0.015	0.036	0.043	0.074	0.11	0.058	0.115	0.119	0.046	0.059	0.071	0.079	0.07	0.075
Bicarbonate as $CaCO_3$	mg/L	NS	NS	80.80	74.78	63.22	69.42	69.00	73.39	74.64	78.08	81.06	77.56	77.46	73.86	68.60	76.83

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	13/10/2004	20/10/2004	27/10/2004	01/11/2004	03/11/2004	10/11/2004	17/11/2004	24/11/2004	01/12/2004	08/12/2004	15/12/2004	20/12/2004	22/12/2004	30/12/2004
Calcium, Ca	mg/L	<32	NS	63.787	62.419	64.854	23.3	49.829	54.384	53.508	55.107	57.104	35.833	35.777	22.558	51.473	46.195
Chloride, Cl	mg/L	<100	<300	62.227	69.268	71.614	139	45.036	51.898	53.15	45.243	53.986	31.765	37.616	18.055	63.553	29.752
Conductivity mS/m @ 25 °C	mS/m	<70	<170	85	89.6	98.3	62	72.6	79.9	83.1	78.3	85.5	57	59.7	38.5	83.5	61.1
Fluoride, F	mg/L	1	1.5	0.228	0.223	0.376	0.4	0.422	0.303	0.301	0.236	0.274	0.451	0.516	0.378	0.629	0.523
Potassium, K	mg/L	<50	NS	6.006	10.139	12.639	6.9	8.987	8.354	8.539	6.157	7.639	7.745	10.609	6.994	15.607	6.218
Magnesium, Mg (mg/l)	mg/L	<30	NS	55.134	56.155	53.011	11.5	36.36	44.867	48.32	50.492	52.243	31.389	30.429	17.413	41.466	34.474
Sodium, Na	mg/L	<100	<200	43.253	55.901	62.379	43.1	35.132	39.754	42.231	34.526	42.372	24.801	30.136	17.656	53.822	24.738
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.055	0.347	0.055	0.6	0.422	0.284	0.055	0.055	0.114	0.476	0.694	0.642	1.844	0.518
pH at 22 °C	pH units	6-9	5-9.7	8.336	8.4	8.011	8.2	7.933	8.09	8.051	8.14	8.117	8.075	7.988	7.939	8.152	8.046
Sulphate, SO_4	mg/L	<200	<500	111.078	116.8	96.647	1020	97.407	97.449	91.549	88.607	107.918	81.449	70.969	38.029	95.289	86.474
Ammonium, NH_4	mg/L	<1.0	<1.5	0.078	0.117	0.148	1.9	0.197	0.082	0.089	0.072	0.082	0.097	0.158	0.015	0.292	0.015
Bicarbonate as $CaCO_3$	mg/L	NS	NS	77.82	76.15	79.12	28.43	60.79	66.35	65.28	67.23	69.67	43.72	43.65	27.52	62.80	56.36

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	05/01/2005	12/01/2005	19/01/2005	26/01/2005	02/02/2005	09/02/2005	16/02/2005	23/02/2005	02/03/2005	04/03/2005	09/03/2005	16/03/2005	31/03/2005	01/04/2005
Calcium, Ca	mg/L	<32	NS	49.187	58.064	39.718	42.633	52.845	58.036	50.059	44.252	52.154	48.9	55.221	56.324	50.35	50.483
Chloride, Cl	mg/L	<100	<300	35.995	52.565	33.86	27.984	36.755	66.057	53.043	60.255	41.112	55	57.473	59.374	27.42	29.623
Conductivity mS/m @ 25 °C	mS/m	<70	<170	67.5	83.3	57.3	56.2	69.6	83	75.6	67.1	73.9	75	83	76.8	66.8	68.7
Fluoride, F	mg/L	1	1.5	0.32	0.476	0.59	0.54	0.293	0.397	0.381	0.343	0.338	0.5	0.366	0.292	0.242	0.286
Potassium, K	mg/L	<50	NS	5.28	8.035	7.747	6.376	5.383	8.102	8.505	8.762	6.174	6.9	8.634	8.663	4.417	4.443
Magnesium, Mg (mg/l)	mg/L	<30	NS	44.976	48.285	27.668	35.895	41.779	49.147	44.544	38.616	44.453	47.7	49.01	46.621	43.403	44.03
Sodium, Na	mg/L	<100	<200	26.866	39.738	26.15	18.8	24.669	39.926	35.293	35.322	33.414	35.7	44.191	42.432	24.886	26.083
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.205	0.055	1.069	0.055	0.334	0.706	0.672	1.081	0.545	0.7	0.708	0.459	0.04	0.221
pH at 22 °C	pH units	6-9	5-9.7	7.499	8.064	7.992	7.883	8.059	8.089	8.056	7.948	8.104	8	8.044	8.13	8.066	8.043
Sulphate, SO_4	mg/L	<200	<500	90.883	126.633	69.529	81.524	85.484	95.841	90.316	80.26	88.573	96	97.62	94.919	89.297	88.903
Ammonium, NH_4	mg/L	<1.0	<1.5	0.099	0.015	0.038	0.015	0.043	0.051	0.078	0.048	0.046	0.3	0.052	0.02	0.02	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	60.01	70.84	48.46	52.01	64.47	70.80	61.07	53.99	63.63	59.66	67.37	68.72	61.43	61.59

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	12/04/2005	20/04/2005	22/04/2005	27/04/2005	04/05/2005	18/05/2005	25/05/2005	01/06/2005	01/06/2005	08/06/2005	08/06/2005	15/06/2005	22/06/2005	01/07/2005
Calcium, Ca	mg/L	<32	NS	34	51.421	49.034	52.395	48.96	54.747	57.985	56.446	61.305	58.509	52.9	58.229	59.718	59.681
Chloride, Cl	mg/L	<100	<300	41	37.053	34.209	39.503	37.85	34.92	40.115	31.626	42.342	30.246	42	30.501	39.294	37.394
Conductivity mS/m @ 25 °C	mS/m	<70	<170	69	72	73.3	69.9	71.7	76	74.8	75.7	79.5	76.3	74	76.4	76.2	75.4
Fluoride, F	mg/L	1	1.5	0.05	0.295	0.286	0.329	0.295	0.27	0.313	0.251	0.234	0.214	0.3	0.209	0.213	0.212
Potassium, K	mg/L	<50	NS	4.8	5.231	4.993	4.8	4.191	5.017	4.742	4.549	5.122	4.503	4.8	5.115	6.243	4.513
Magnesium, Mg (mg/l)	mg/L	<30	NS	29.4	41.562	45.688	41.537	43.367	42.429	45.836	46.341	47.954	46.685	25.9	47.156	47.628	48.757
Sodium, Na	mg/L	<100	<200	27.7	28.248	29.745	28.635	29.96	32.889	30.607	29.287	33.218	27.702	29.8	28.312	35.473	29.892
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.05	0.303	0.243	0.431	0.223	0.469	0.266	0.465	0.688	0.512	10.4	0.438	0.67	0.484
pH at 22 °C	pH units	6-9	5-9.7	8.2	7.906	8.137	7.976	8.014	7.878	8.159	8.149	8.286	8.261	7.6	8.144	8.449	8.143
Sulphate, SO_4	mg/L	<200	<500	98	88.122	84.214	87.454	87.474	96.757	97.88	84.022	102.003	87.217	98	89.752	98.179	107.671
Ammonium, NH_4	mg/L	<1.0	<1.5	0.05	0.02	0.02	0.047	0.043	0.043	0.02	0.126	0.02	0.08	0.05	0.075	0.071	0.065
Bicarbonate as $CaCO_3$	mg/L	NS	NS	41.48	62.73	59.82	63.92	59.73	66.79	70.74	68.86	74.79	71.38	64.54	71.04	72.86	72.81

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	01/07/2005	06/07/2005	13/07/2005	20/07/2005	27/07/2005	01/08/2005	03/08/2005	10/08/2005	17/08/2005	17/08/2005	24/08/2005	31/08/2005	01/09/2005	08/09/2005
Calcium, Ca	mg/L	<32	NS	61.052	58.572	61.906	61.22	61.971	63.754	63.672	62.645	63.713	60.049	62.845	58.122	61.858	62.194
Chloride, Cl	mg/L	<100	<300	38.465	43.125	36.965	37.419	36.443	44.031	42.028	40.321	42.242	80.479	56.531	44.379	44.707	54.151
Conductivity mS/m @ 25 °C	mS/m	<70	<170	74.1	76.6	76	78.8	78.6	80.1	82.1	81.1	81.3	83	84.9	82.7	83.4	86
Fluoride, F	mg/L	1	1.5	0.182	0.204	0.234	0.228	0.209	0.18	0.151	0.207	0.199	0.351	0.204	0.23	0.268	0.187
Potassium, K	mg/L	<50	NS	4.513	4.552	4.631	5.587	5.295	4.951	5.928	5.873	5.754	13.757	7.047	6.328	6.533	7.796
Magnesium, Mg (mg/l)	mg/L	<30	NS	47.972	47.106	48.446	49.042	48.649	48.552	47.539	47.874	53.772	23.245	50.295	51.092	49.758	53.834
Sodium, Na	mg/L	<100	<200	30.708	31.823	31.905	30.955	30.922	32.551	36.112	34.508	33.896	66.712	38.763	35.746	38.243	41.929
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.435	0.76	0.79	1.178	0.763	0.566	0.794	0.717	0.956	1.095	1.872	1.213	0.988	1.151
pH at 22 °C	pH units	6-9	5-9.7	8.234	8.219	8.256	8.274	8.264	8.287	8.338	8.182	8.158	8.051	8.104	8.335	8.233	8.272
Sulphate, SO_4	mg/L	<200	<500	101.366	96.03	100.413	93.628	96.159	90.017	105.32	108.197	99.339	151.848	99.13	96.807	107.541	109.719
Ammonium, NH_4	mg/L	<1.0	<1.5	0.047	0.055	0.752	0.278	0.053	0.02	0.02	0.06	0.124	0.168	0.101	0.07	0.044	0.047
Bicarbonate as $CaCO_3$	mg/L	NS	NS	74.48	71.46	75.53	74.69	75.60	77.78	77.68	76.43	77.73	73.26	76.67	70.91	75.47	75.88

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	14/09/2005	21/09/2005	28/09/2005	01/10/2005	05/10/2005	11/10/2005	19/10/2005	26/10/2005	26/10/2005	28/10/2005	02/11/2005	23/11/2005	30/11/2005	07/12/2005
Calcium, Ca	mg/L	<32	NS	61.905	60.903	59.397	66.8	64.134	59.7	56.424	63.759	36.5	56.813	58.267	78.335	59.044	50.396
Chloride, Cl	mg/L	<100	<300	52.825	50.762	50.854	72.053	64.627	59.778	51.873	64.632	66	61.871	67.194	71.939	63.934	52.205
Conductivity mS/m @ 25 °C	mS/m	<70	<170	87.6	85.6	87.6	95.6	91.5	90.2	85.4	90.7	90	90.4	91.3	104	86.7	84.7
Fluoride, F	mg/L	1	1.5	0.259	0.248	0.226	0.215	0.227	0.217	0.231	0.222	0.5	0.243	0.228	0.24	0.223	0.224
Potassium, K	mg/L	<50	NS	7.832	6.594	8.789	11.392	9.64	11.361	10.862	11.956	11.8	9.672	10.332	11.594	11.318	9.357
Magnesium, Mg (mg/l)	mg/L	<30	NS	50.942	51.404	52.041	55.363	51.296	52.145	52.042	58.028	47.6	57.157	57.011	65.389	51.259	49.089
Sodium, Na	mg/L	<100	<200	44.959	41.858	45.865	60.599	54.512	50.918	42.394	50.018	54	48.575	49.66	58.588	51.768	49.687
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.947	0.04	0.04	0.114	0.04	0.876	0.085	0.04	0.05	0.04	0.04	0.04	0.04	0.04
pH at 22 °C	pH units	6-9	5-9.7	8.051	8.386	8.341	8.422	8.351	8.121	8.115	8.145	7.6	8.331	8.036	8.246	8.106	8.064
Sulphate, SO_4	mg/L	<200	<500	114.239	101.159	109.697	128.411	112.217	124.645	101.943	92.153	106	99.003	95.9	151.948	123.571	107.581
Ammonium, NH_4	mg/L	<1.0	<1.5	0.051	0.045	0.02	0.02	0.041	0.049	0.053	0.02	1	0.124	0.02	0.02	0.074	0.07
Bicarbonate as $CaCO_3$	mg/L	NS	NS	75.52	74.30	72.46	81.50	78.24	72.83	68.84	77.79	44.53	69.31	71.09	95.57	72.03	61.48

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	08/12/2005	29/12/2005	03/01/2006	11/01/2006	11/01/2006	18/01/2006	25/01/2006	01/02/2006	01/02/2006	01/02/2006	08/02/2006	15/02/2006	21/02/2006	22/02/2006
Calcium, Ca	mg/L	<32	NS	62.7	54.277	37.093	41.379	30.1	53.439	25.823	43.248	28.9	57.616	51.677	41.805	19.7	51.849
Chloride, Cl	mg/L	<100	<300	56	60.722	49.521	55.002	56	45.683	24.866	34.578	38	52.669	48.132	31.581	44	42.189
Conductivity mS/m @ 25 °C	mS/m	<70	<170	81	83.2	64.2	70.6	71	74.2	43.8	66.8	63	80.7	79.6	59.4	72	75.8
Fluoride, F	mg/L	1	1.5	0.05	0.268	0.275	0.361	0.4	0.355	0.326	0.351	0.5	0.394	0.305	0.302	0.4	0.268
Potassium, K	mg/L	<50	NS	9.8	9.196	6.208	8.476	10.1	7.429	7.906	6.651	5.4	8.314	7.899	8.609	5.2	6.924
Magnesium, Mg (mg/l)	mg/L	<30	NS	45.5	52.516	33.033	33.73	33.8	42.111	20.09	35.753	33.6	46.277	48.403	31.582	38.1	45.262
Sodium, Na	mg/L	<100	<200	45.4	47.966	38.972	44.654	52.6	34.724	23.177	27.082	24.3	42.03	39.791	25.33	30.4	34.44
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.05	0.04	0.102	0.26	0.4	0.253	0.04	0.309	0.5	0.04	0.22	0.333	0.2	0.282
pH at 22 °C	pH units	6-9	5-9.7	7.9	8.138	7.979	8	7.7	8.325	7.417	8.017	7.8	8.022	8.471	7.904	7.8	8.157
Sulphate, SO_4	mg/L	<200	<500	118	131.889	96.633	90.785	108	115.995	51.568	85.068	102	102.532	97.511	57.631	105	89.706
Ammonium, NH_4	mg/L	<1.0	<1.5	0.2	0.02	0.054	0.02	0.5	0.041	0.053	0.051	0.3	0.02	0.219	0.082	0.2	0.062
Bicarbonate as $CaCO_3$	mg/L	NS	NS	76.49	66.22	45.25	50.48	36.72	65.20	31.50	52.76	35.26	70.29	63.05	51.00	24.03	63.26

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	01/03/2006	08/03/2006	15/03/2006	22/03/2006	29/03/2006	05/04/2006	12/04/2006	19/04/2006	26/04/2006	03/05/2006	08/05/2006	09/05/2006	17/05/2006	19/05/2006
Calcium, Ca	mg/L	<32	NS	38.46	44.537	57.088	41.647	34.188	46.17	27.324	43.516	48.503	58.176	39.3	53.492	61.048	52.308
Chloride, Cl	mg/L	<100	<300	27.562	51.589	44.353	37.187	32.221	47.933	18.227	40.261	36.173	36.852	46	44.467	36.893	44.417
Conductivity mS/m @ 25 °C	mS/m	<70	<170	53.6	67.2	80	59.3	52	71.8	37.3	65.2	65.2	69.1	76	71.4	69.8	71.6
Fluoride, F	mg/L	1	1.5	0.292	0.241	0.249	0.229	0.304	0.237	0.222	0.324	0.232	0.18	0.05	0.232	0.197	0.222
Potassium, K	mg/L	<50	NS	7.099	6.4	6.51	4.832	4.84	4.635	5.075	4.826	4.217	2.35	4.9	5.187	3.444	4.971
Magnesium, Mg (mg/l)	mg/L	<30	NS	29.365	38.266	45.179	34.799	28.866	44.862	19.733	35.909	44.424	44.387	40.3	47.502	46.587	48.266
Sodium, Na	mg/L	<100	<200	21.821	36.335	37.011	26.326	24.528	36.165	15.599	33.165	26.18	30.268	50.9	33.837	30.742	33.562
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.04	0.601	0.268	0.194	0.097	0.271	0.04	0.04	0.04	0.331	0.5	0.919	0.421	0.812
pH at 22 °C	pH units	6-9	5-9.7	8.083	8.099	8.037	7.873	7.528	8.05	7.972	8.204	8.323	8.56	7.5	8.212	8.243	8.3
Sulphate, SO_4	mg/L	<200	<500	55.452	90.065	98.063	73.141	62.284	105.32	41.356	85.048	86.76	93.328	101	91.613	102.116	94.55
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.133	0.02	0.047	0.06	0.02	0.02	0.02	0.057	0.2	0.046	0.046	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	46.92	54.34	69.65	50.81	41.71	56.33	33.34	53.09	59.17	70.97	47.95	65.26	74.48	63.82

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	21/05/2006	31/05/2006	07/06/2006	07/06/2006	14/06/2006	19/06/2006	21/06/2006	28/06/2006	05/07/2006	12/07/2006	12/07/2006	12/07/2006	19/07/2006	26/07/2006
Calcium, Ca	mg/L	<32	NS	56.408	60.497	59.994	40.5	60.122	31.9	63.969	61.692	61.023	61.466	58.2	58.2	61.18	62.287
Chloride, Cl	mg/L	<100	<300	46.788	37.65	39.872	40	36.36	38	39.657	36.721	40.2	34.463	44	44	48.671	43.791
Conductivity mS/m @ 25 °C	mS/m	<70	<170	74.8	70.3	76.2	77	76.2	76	74.8	70.4	75.1	75.2	75	75	75.8	74
Fluoride, F	mg/L	1	1.5	0.281	0.196	0.211	0.05	0.202	0.05	0.19	0.214	0.199	0.23	0.05	0.05	0.211	0.23
Potassium, K	mg/L	<50	NS	4.916	4.27	4.346	4.1	3.81	5	4.375	4.229	4.317	4.177	4.1	4.1	4.788	6.005
Magnesium, Mg (mg/l)	mg/L	<30	NS	48.497	49.735	42.471	40.1	46.905	46.8	48.224	47.404	47.614	48.821	45.6	45.6	47.515	48.012
Sodium, Na	mg/L	<100	<200	33.901	30.548	32.423	32.1	27.764	32.9	30.346	29.702	30.068	29.512	35.6	35.6	31.466	36.774
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.741	0.367	0.244	0.05	0.248	0.2	0.25	0.241	0.378	0.235	0.2	0.2	0.307	0.481
pH at 22 °C	pH units	6-9	5-9.7	8.183	8.395	8.557	8.7	8.316	8.2	8.333	8.405	8.379	8.202	8.1	8.1	8.273	8.219
Sulphate, SO_4	mg/L	<200	<500	106.256	96.8	95.652	106	85.118	98	91.48	95.255	96.684	90.939	103	103	106.356	91.25
Ammonium, NH_4	mg/L	<1.0	<1.5	0.05	0.02	0.02	0.4	0.02	0.2	0.047	0.02	0.02	0.071	0.05	0.05	0.059	0.057
Bicarbonate as $CaCO_3$	mg/L	NS	NS	68.82	73.81	73.19	49.41	73.35	38.92	78.04	75.26	74.45	74.99	71.00	71.00	74.64	75.99

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	01/08/2006	02/08/2006	16/08/2006	16/08/2006	22/08/2006	23/08/2006	23/08/2006	26/08/2006	27/08/2006	30/08/2006	02/09/2006	06/09/2006	13/09/2006	20/09/2006
Calcium, Ca	mg/L	<32	NS	25.595	59.322	58.894	59.5	69.116	63.034	66.526	65.749	69.536	64.806	66.661	65.174	57.034	62.9
Chloride, Cl	mg/L	<100	<300	17.373	41.26	45.739	54	46.065	40.123	47.225	44.495	46.605	46.543	48.591	53.804	36.217	46.951
Conductivity mS/m @ 25 °C	mS/m	<70	<170	32.1	74	77.9	80	78.5	73.1	80.9	74.3	75.3	74	82.3	77.8	73.6	78.1
Fluoride, F	mg/L	1	1.5	0.171	0.19	0.224	0.2	0.18	0.171	0.218	0.179	0.18	0.25	0.232	0.245	0.175	0.252
Potassium, K	mg/L	<50	NS	3.755	5.829	4.939	5.6	6.029	5.3	5.884	5.857	5.646	5.226	6.198	5.876	4.957	6.554
Magnesium, Mg (mg/l)	mg/L	<30	NS	10.419	46.635	47.162	47	51.956	49.762	51.059	49.091	49.562	46.577	52.068	51.811	52.025	50.368
Sodium, Na	mg/L	<100	<200	19.099	35.532	35.33	36.8	38.047	33.382	35.983	36.567	36.551	35.785	40.66	40.158	28.715	37.987
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	4.098	0.487	0.177	0.2	1.021	0.358	0.989	0.994	0.99	0.685	1.501	0.961	0.589	1.299
pH at 22 °C	pH units	6-9	5-9.7	7.831	8.458	8.46	8	8.397	8.386	8.51	8.332	8.448	8.407	8.099	8.236	8.302	8.432
Sulphate, SO_4	mg/L	<200	<500	17.86	99.164	100.693	106	104.788	104.704	110.687	105.284	98.798	101.89	104.981	103.845	118.612	99.697
Ammonium, NH_4	mg/L	<1.0	<1.5	0.233	0.076	0.073	0.5	0.07	0.067	0.08	0.07	0.05	0.107	0.02	0.132	0.106	0.11
Bicarbonate as $CaCO_3$	mg/L	NS	NS	31.23	72.37	71.85	72.59	84.32	76.90	81.16	80.21	84.83	79.06	81.33	79.51	69.58	76.74

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	20/09/2006	27/09/2006	01/10/2006	04/10/2006	11/10/2006	11/10/2006	20/10/2006	25/10/2006	01/11/2006	01/11/2006	08/11/2006	10/11/2006	10/11/2006	15/11/2006
Calcium, Ca	mg/L	<32	NS	44	68.568	66.121	69.47	62.957	46.9	60.267	59.394	63.043	55.735	58.413	48.1	48.1	26.504
Chloride, Cl	mg/L	<100	<300	49	61.092	68.401	68.477	68.681	55	53.038	67.315	67.806	47.458	51.857	63	63	34.038
Conductivity mS/m @ 25 °C	mS/m	<70	<170	82	81.4	95.8	85.8	91.3	90	83.9	92.3	91.7	83.1	78.7	90	90	42.7
Fluoride, F	mg/L	1	1.5	0.2	0.276	0.224	0.279	0.262	0.2	0.384	0.323	0.31	0.262	0.258	-	-	0.217
Potassium, K	mg/L	<50	NS	5.6	7.932	9.166	9.388	9.593	9.6	8.055	9.821	10.821	9.176	7.252	0.9	0.9	8.686
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.7	51.733	49.447	53.619	51.609	43.9	50.213	53.677	51.175	48.095	48.823	44.2	44.2	21.639
Sodium, Na	mg/L	<100	<200	35.4	49.023	56.894	55.957	64.433	47.1	42.238	46.479	53.455	39.934	43.55	59.2	59.2	21.424
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	1.6	1.518	0.668	1.486	0.858	0.9	0.482	0.511	0.532	0.457	0.378	-	0.7	0.595
pH at 22 °C	pH units	6-9	5-9.7	7.9	8.321	8.483	8.183	8.209	7.8	8.774	8.275	8.61	8.123	8.282	7.9	7.9	8.319
Sulphate, SO_4	mg/L	<200	<500	111	109.984	113.296	120.35	122.39	111	126.372	125.064	121.624	105.077	110.06	117	117	69.255
Ammonium, NH_4	mg/L	<1.0	<1.5	0.2	0.103	0.108	0.084	0.126	0.3	0.02	0.02	0.02	0.02	0.102	0.05	0.05	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	53.68	83.65	80.67	84.75	76.81	57.22	73.53	72.46	76.91	68.00	71.26	58.68	58.68	32.33

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	15/11/2006	22/11/2006	24/11/2006	29/11/2006	04/12/2006	05/12/2006	06/12/2006	06/12/2006	07/12/2006	08/12/2006	09/12/2006	10/12/2006	11/12/2006	12/12/2006
Calcium, Ca	mg/L	<32	NS	23.3	53.668	49.476	54.172	54.039	51.562	56.611	53.585	52.651	57.005	56.319	48.217	49.367	47.6
Chloride, Cl	mg/L	<100	<300	40	56.666	52.209	50.373	44.544	45.25	52.915	45.336	45.621	46.01	45.846	45.38	42.358	51
Conductivity mS/m @ 25 °C	mS/m	<70	<170	45	81.1	75.2	76.6	75.3	77.8	80.9	78	75.6	75.5	75.2	74.9	75.2	81
Fluoride, F	mg/L	1	1.5	0.2	0.281	0.326	0.281	0.244	0.256	0.158	0.242	0.238	0.247	0.246	0.238	0.292	0.2
Potassium, K	mg/L	<50	NS	8.8	6.916	7.142	5.693	6.109	6.243	6.035	5.877	5.733	7.044	6.072	6.018	7.786	7.6
Magnesium, Mg (mg/l)	mg/L	<30	NS	19.9	47.994	41.215	46.169	44.043	46.647	48.332	47.756	45.395	44.792	44.97	45.946	43.128	42.2
Sodium, Na	mg/L	<100	<200	22.5	48.85	44.927	40.063	35.404	36.664	43.965	39.229	36.168	35.888	36.182	36.487	35.709	53
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.9	0.146	0.449	0.316	0.467	0.405	0.337	0.372	0.489	0.426	1.222	0.246	1.045	0.6
pH at 22 °C	pH units	6-9	5-9.7	7.1	8.087	8.163	8.102	8.108	8.087	8.244	8.217	8.002	8.032	8.236	8.206	8.218	8
Sulphate, SO_4	mg/L	<200	<500	64	137.854	109.55	121.448	98.37	98.279	118.633	106.68	99.902	97.485	101.148	98.777	109.266	104
Ammonium, NH_4	mg/L	<1.0	<1.5	0.3	0.071	0.02	0.058	0.074	0.099	0.11	0.09	0.063	0.104	0.084	0.12	0.142	0.05
Bicarbonate as $CaCO_3$	mg/L	NS	NS	28.43	65.47	60.36	66.09	65.93	62.91	69.07	65.37	64.23	69.55	68.71	58.82	60.23	58.07

Exceed the DWA SAWQTV standards
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Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	12/12/2006	13/12/2006	13/12/2006	14/12/2006	15/12/2006	16/12/2006	17/12/2006	20/12/2006	01/01/2007	04/01/2007	10/01/2007	15/01/2007	17/01/2007	24/01/2007
Calcium, Ca	mg/L	<32	NS	50.933	50.631	52.02	55.486	49.483	55.188	50.462	48.639	43.461	45.356	44.842	54.6	50.605	35.797
Chloride, Cl	mg/L	<100	<300	45.323	56.489	45.838	51.085	45.395	51.047	47.74	45.43	41.351	40.613	50.324	60	51.843	53.532
Conductivity mS/m @ 25 °C	mS/m	<70	<170	75.2	82.9	75.3	75.4	75.6	75.2	75.7	75.7	70.4	65.2	71.3	81	73.1	66.4
Fluoride, F	mg/L	1	1.5	0.306	0.238	0.328	0.289	0.357	0.307	0.375	0.305	0.221	0.291	0.267	0.3	0.244	0.288
Potassium, K	mg/L	<50	NS	7.756	9.277	7.55	7.233	7.614	7.339	7.49	7.304	4.868	4.41	5.271	6.7	6.024	6.331
Magnesium, Mg (mg/l)	mg/L	<30	NS	42.572	43.526	43.158	45.365	41.82	44.27	43.897	43.084	38.687	35.604	40.991	41.6	41.359	30.949
Sodium, Na	mg/L	<100	<200	35.041	46.492	38.566	36.743	35.056	36.535	37.928	35.599	37.068	35.009	42.701	43.7	39.957	46.743
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	1.058	0.506	1.067	1.012	1.035	1.028	1.137	0.279	0.2	0.132	0.352	0.4	0.275	0.121
pH at 22 °C	pH units	6-9	5-9.7	8.214	8.229	8.168	8.217	8.166	8.237	8.25	8.23	8.322	8.31	8.273	7.7	8.155	8.085
Sulphate, SO_4	mg/L	<200	<500	104.333	107.012	97.327	101.24	104.902	105.444	97.705	105.229	85.985	77.464	96.234	98	92.845	100.287
Ammonium, NH_4	mg/L	<1.0	<1.5	0.138	0.02	0.14	0.135	0.144	0.139	0.137	0.02	0.094	0.087	0.06	0.2	0.105	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	62.14	61.77	63.46	67.69	60.37	67.33	61.56	59.34	53.02	55.33	54.71	66.61	61.74	43.67

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	25/01/2007	31/01/2007	07/02/2007	14/02/2007	21/02/2007	22/02/2007	28/02/2007	07/03/2007	14/03/2007	21/03/2007	28/03/2007	30/03/2007	01/04/2007	02/04/2007
Calcium, Ca	mg/L	<32	NS	34.4	46.367	50.842	48.37	50.08	40.4	48.873	43.864	56.963	59.977	66.389	58.685	56.682	60.337
Chloride, Cl	mg/L	<100	<300	61	60.365	69.77	61.9	64.129	66	73.293	47.09	70.28	80.538	89.787	66.779	74.485	73.665
Conductivity mS/m @ 25 °C	mS/m	<70	<170	72	75	82.1	81.5	82.6	81	89.9	69.9	90	92.6	102.2	86.9	82.3	82.1
Fluoride, F	mg/L	1	1.5	0.3	0.302	0.324	0.264	0.362	0.3	0.359	0.322	0.437	0.424	0.298	0.237	0.259	0.249
Potassium, K	mg/L	<50	NS	7.3	8.851	9.935	9.701	9.495	9.7	12.463	7.988	10.609	10.688	11.828	11.087	10.452	10.562
Magnesium, Mg (mg/l)	mg/L	<30	NS	31.5	35.328	40.321	42.201	45.625	43.7	44.354	36.749	46.559	49.312	53.804	45.447	45.206	44.696
Sodium, Na	mg/L	<100	<200	39.7	59.357	55.669	53.601	52.347	59.5	63.531	38.917	58.107	61.743	70.408	58.56	57.503	57.326
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.05	0.241	0.142	0.276	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.222	0.211	0.221
pH at 22 °C	pH units	6-9	5-9.7	8.1	8.127	8.361	8.238	8.442	8.6	8.375	8.099	8.101	8.085	8.367	8.196	8.276	8.306
Sulphate, SO_4	mg/L	<200	<500	94	90.388	102.006	106.465	102.816	100	94.828	69.718	92.164	91.108	104.525	119.46	115.71	115.538
Ammonium, NH_4	mg/L	<1.0	<1.5	0.3	0.049	0.072	0.122	0.09	0.2	0.096	0.123	0.1	0.128	0.123	0.091	0.119	0.127
Bicarbonate as $CaCO_3$	mg/L	NS	NS	41.97	56.57	62.03	59.01	61.10	49.29	59.63	53.51	69.49	73.17	80.99	71.60	69.15	73.61

Exceed the DWA SAWQTV standards
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Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	03/04/2007	04/04/2007	13/04/2007	14/04/2007	15/04/2007	18/04/2007	25/04/2007	01/05/2007	02/05/2007	08/05/2007	09/05/2007	16/05/2007	23/05/2007	01/06/2007
Calcium, Ca	mg/L	<32	NS	36.4	59.323	49.615	56.521	52.863	47.525	49.097	59.887	53.478	53.6	57.401	59.759	55.44	60.012
Chloride, Cl	mg/L	<100	<300	64	68.63	65.203	85.435	84.691	58.677	57.106	73.207	73.248	62	63.405	69.519	54.556	62.554
Conductivity mS/m @ 25 °C	mS/m	<70	<170	87	90.6	79.1	85.9	87.8	76.4	72	85.6	87.5	91	87.3	88.9	77.9	83.8
Fluoride, F	mg/L	1	1.5	0.3	0.287	0.274	0.263	0.291	0.26	0.632	0.79	0.694	0.4	0.357	0.308	0.232	0.184
Potassium, K	mg/L	<50	NS	14	10.911	9.954	9.206	8.996	8.998	8.201	9.528	8.74	8.6	9.103	9.828	7.615	7.267
Magnesium, Mg (mg/l)	mg/L	<30	NS	46.2	43.271	47.15	48.851	51.206	45.154	40.149	49.29	49.681	60.1	50.416	50.635	52.766	50.824
Sodium, Na	mg/L	<100	<200	38.9	55.299	56.66	61.361	60.971	53.462	40.696	60.208	56.297	41.3	53.87	54.084	44.281	51.536
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.3	0.04	0.04	0.04	0.13	0.515	0.868	0.933	0.946	0.7	0.767	0.276	0.489	0.772
pH at 22 °C	pH units	6-9	5-9.7	7.8	8.132	8.271	8.594	8.205	8.218	8.107	8.143	8.216	8.4	8.414	8.321	8.387	8.172
Sulphate, SO_4	mg/L	<200	<500	123	139.314	107.573	121.963	103.331	110.333	99.513	115.224	115.082	121	122.722	118.926	108.095	110.742
Ammonium, NH_4	mg/L	<1.0	<1.5	0.05	0.117	0.101	0.12	0.067	0.083	0.114	0.086	0.113	0.4	0.09	0.087	0.082	0.1
Bicarbonate as $CaCO_3$	mg/L	NS	NS	44.41	72.37	60.53	68.96	64.49	57.98	59.90	73.06	65.24	65.39	70.03	72.91	67.64	73.21

Exceed the DWA SAWQTV standards
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Parameter (mg/l)	*Unit*	DWA SAWQTV Drinking Water	SANS 241-1: 2011	06/06/2007	07/06/2007	14/06/2007	20/06/2007	21/06/2007	27/06/2007	04/07/2007	11/07/2007	16/07/2007	18/07/2007	25/07/2007	01/08/2007	08/08/2007	16/08/2007
Calcium, Ca	mg/L	<32	NS	55.186	48.6	62.243	56.376	54.7	55.031	52.87	56.8	45.6	65.32	61.879	66.733	66.234	63.498
Chloride, Cl	mg/L	<100	<300	55.095	67	60.127	40.987	45	46.403	45.922	56.125	47	49.632	45.256	61.221	62.652	43.432
Conductivity mS/m @ 25 °C	mS/m	<70	<170	79.7	90	82.4	78.1	82	80.3	72.7	78.2	80	80	80	86.9	88.9	74.8
Fluoride, F	mg/L	1	1.5	0.188	0.2	0.303	0.187	0.05	0.184	0.166	0.192	0.05	0.181	0.181	0.255	0.221	0.187
Potassium, K	mg/L	<50	NS	7.137	8.4	7.673	5.764	5.2	5.645	5.087	5.888	5.7	4.826	5.29	7.037	7.577	6.371
Magnesium, Mg (mg/l)	mg/L	<30	NS	50.193	49.7	52.875	50.459	49.5	53.021	46.55	50.901	47.9	49.98	51.159	51.888	53.547	50.581
Sodium, Na	mg/L	<100	<200	46.379	51.8	46.837	35.673	24.4	38.884	34.381	41.95	39.4	34.441	36.094	46.813	51.096	36.888
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.166	-	0.371	0.141	0.05	0.122	3.937	0.081	0.05	0.04	0.225	0.9	0.746	0.04
pH at 22 °C	pH units	6-9	5-9.7	8.152	7.8	8.201	8.295	8.2	8.225	7.729	8.321	8.6	8.254	8.203	8.327	8.556	8.574
Sulphate, SO_4	mg/L	<200	<500	107.746	125	117.512	117.786	120	117.741	93.268	120.686	130	111.449	116.887	128.901	130.255	114.926
Ammonium, NH_4	mg/L	<1.0	<1.5	0.075	0.2	0.078	0.123	0.05	0.276	0.124	0.089	0.2	0.153	0.098	0.196	0.1	0.126
Bicarbonate as $CaCO_3$	mg/L	NS	NS	67.33	59.29	75.94	68.78	66.73	67.14	64.50	69.30	55.63	79.69	75.49	81.41	80.81	77.47

Exceed the DWA SAWQTV standards

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Parameter (mg/l)	*Unit*	DWA SAWQTV Drinking Water	SANS 241-1: 2011	22/08/2007	23/08/2007	27/08/2007	28/08/2007	29/08/2007	29/08/2007	30/08/2007	31/08/2007	01/09/2007	02/09/2007	03/09/2007	04/09/2007	05/09/2007	06/09/2007
Calcium, Ca	mg/L	<32	NS	61.501	46	62.51	63.405	69.09	67.122	61.085	66.431	68.23	63.713	63.868	62.923	62.193	65.801
Chloride, Cl	mg/L	<100	<300	54.593	52	84.783	65.808	50.346	51.558	44.683	44.131	46.276	50.514	59.039	55.077	58.343	48.406
Conductivity mS/m @ 25 °C	mS/m	<70	<170	87.5	83	94.9	87.9	84.4	80.9	85.8	84.5	84.8	87.6	90.7	90.8	90.1	85.5
Fluoride, F	mg/L	1	1.5	0.198	0.2	0.253	0.241	0.195	0.176	0.173	0.17	0.18	0.173	0.211	0.202	0.25	0.18
Potassium, K	mg/L	<50	NS	6.749	6.1	8.29	6.64	5.551	5.55	5.232	5.227	5.511	5.713	6.474	6.372	5.97	5.428
Magnesium, Mg (mg/l)	mg/L	<30	NS	53.541	51.7	53.979	53.787	50.795	53.261	49.279	49.749	53.174	49.744	51.535	51.238	50.109	50.793
Sodium, Na	mg/L	<100	<200	45.782	40.7	61.288	45.214	35.588	34.843	34.68	34.51	36.146	38.692	42.855	42.742	42.861	38.642
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.337	0.05	1.147	0.813	0.58	0.631	0.04	0.213	0.24	0.04	0.04	0.04	0.04	0.095
pH at 22 °C	pH units	6-9	5-9.7	8.364	8.7	8.033	8.153	8.314	8.316	8.068	8.599	8.263	8	8.345	8.041	8.171	8.283
Sulphate, SO_4	mg/L	<200	<500	112.185	107	138.892	139.921	119.815	144.487	104.721	102.874	119.72	103.151	111.441	104.065	104.51	110.012
Ammonium, NH_4	mg/L	<1.0	<1.5	0.122	0.05	0.137	0.134	0.096	0.121	0.139	0.162	0.143	0.156	0.162	0.095	0.144	0.126
Bicarbonate as $CaCO_3$	mg/L	NS	NS	75.03	56.12	76.26	77.35	84.29	81.89	74.52	81.05	83.24	77.73	77.92	76.77	75.88	80.28

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	12/09/2007	19/09/2007	27/09/2007	01/10/2007	10/10/2007	17/10/2007	23/10/2007	24/10/2007	31/10/2007	07/11/2007	14/11/2007	20/11/2007	21/11/2007	21/11/2007
Calcium, Ca	mg/L	<32	NS	71.857	64.773	69.413	44.766	61.96	64.222	45.5	59.142	62.036	70.044	68.34	53.6	61.032	54.743
Chloride, Cl	mg/L	<100	<300	71.792	75.06	77.773	53.165	47.998	52.471	51	44.396	46.88	64.19	58.031	102	64.768	66.042
Conductivity mS/m @ 25 °C	mS/m	<70	<170	90.3	98.3	93.7	69.1	83.6	86.7	78	79.1	80.5	86.7	86.1	105	85.4	86
Fluoride, F	mg/L	1	1.5	0.209	0.209	0.204	0.445	0.305	0.201	0.3	0.228	0.198	0.241	0.272	0.3	0.191	0.203
Potassium, K	mg/L	<50	NS	6.662	7.769	8.639	9.521	5.959	5.353	4.7	5.15	5.091	6.136	5.975	25.6	6.052	7.016
Magnesium, Mg (mg/l)	mg/L	<30	NS	52.489	55.242	52.835	34.167	50.562	50.747	46.3	46.98	49.613	53.558	52.577	23.9	49.733	47.2
Sodium, Na	mg/L	<100	<200	47.923	57.158	62.084	36.848	34.869	38.189	40.3	35.603	36.217	45.736	34.652	79.7	54.738	54.225
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.208	0.184	0.446	0.823	0.479	0.333	0.6	0.356	0.532	0.499	0.315	4.4	0.176	0.04
pH at 22 °C	pH units	6-9	5-9.7	8.04	8.15	8.202	7.609	8.229	7.339	7.8	8.471	8.075	8.14	8.232	7.8	8.136	8.075
Sulphate, SO_4	mg/L	<200	<500	119.136	124.678	114.126	105.515	118.99	115.047	116	104.459	112.879	118.248	113.512	126	110.825	108.22
Ammonium, NH_4	mg/L	<1.0	<1.5	0.262	0.101	0.161	0.674	0.2	0.142	0.3	0.16	0.168	0.141	0.156	0.05	0.076	0.02
Bicarbonate as $CaCO_3$	mg/L	NS	NS	87.67	79.02	84.68	54.61	75.59	78.35	55.51	72.15	75.68	85.45	83.37	65.39	74.46	66.79

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	22/11/2007	28/11/2007	28/11/2007	29/11/2007	06/12/2007	11/12/2007	21/12/2007	26/12/2007	04/01/2008	09/01/2008	16/01/2008	16/01/2008	28/01/2008	30/01/2008
Calcium, Ca	mg/L	<32	NS	58.714	61.811	60.449	53.52	44.545	104.3	54.497	59.8	54.775	65.377	50.688	43.3	59.114	57.319
Chloride, Cl	mg/L	<100	<300	68.128	82.399	82.545	50.336	43.192	35	46.278	54.545	54.701	68.563	61.176	65	71.774	62.587
Conductivity mS/m @ 25 °C	mS/m	<70	<170	85.8	92.5	95.4	77.4	69.1	49	75.7	81.8	79.4	94.4	72.6	75	85.2	82.6
Fluoride, F	mg/L	1	1.5	0.204	0.243	0.255	0.273	0.195	0.2	0.233	0.231	0.198	0.251	0.235	0.2	0.253	0.329
Potassium, K	mg/L	<50	NS	7.147	8.99	9.19	5.986	5.5	7.4	4.837	4.643	4.731	6.652	6.667	7.2	9.845	6.655
Magnesium, Mg (mg/l)	mg/L	<30	NS	47.411	49.371	53.476	46.04	38.468	30.5	45.583	48.369	48.485	50.207	42.438	41.9	47.466	46.28
Sodium, Na	mg/L	<100	<200	55.946	61.502	56.761	48.546	33.135	22.5	34.997	43.897	42.393	58.442	48.494	61.2	65.198	51.597
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.152	0.505	0.388	0.504	0.189	0.5	0.323	0.173	0.089	0.04	0.256	0.05	0.591	0.63
pH at 22 °C	pH units	6-9	5-9.7	8.181	8.313	8.23	8.276	8.549	7.7	8.138	8.263	8.154	8.191	8.241	7.9	8.116	8.169
Sulphate, SO_4	mg/L	<200	<500	109.252	132.494	128.96	110.508	93.281	77	99.446	101.314	90.451	124.249	90.639	92	106.146	114.622
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.065	0.152	0.103	0.09	0.05	0.106	0.084	0.105	0.114	0.118	0.5	0.082	0.129
Bicarbonate as $CaCO_3$	mg/L	NS	NS	71.63	75.41	73.75	65.29	54.34	127.25	66.49	72.96	66.83	79.76	61.84	52.83	72.12	69.93

Exceed the DWA SAWQTV standards
Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	06/02/2008	06/02/2008	12/02/2008	13/02/2008	13/02/2008	20/02/2008	27/02/2008	05/03/2008	11/03/2008	12/03/2008	19/03/2008	27/03/2008	02/04/2008	08/04/2008
Calcium, Ca	mg/L	<32	NS	47.966	51.474	41.9	52.126	52.013	47.583	47.398	47.485	40	44.288	34.812	51.505	48.174	35.2
Chloride, Cl	mg/L	<100	<300	49.969	56.967	58	54.524	54.742	64.169	59.063	46.175	66	64.46	43.058	53.562	46.259	47
Conductivity mS/m @ 25 °C	mS/m	<70	<170	72.2	78.9	75	77.5	82.3	82.2	79.5	65.5	80	71.2	61.3	66.6	67.3	66
Fluoride, F	mg/L	1	1.5	0.212	0.236	0.2	0.202	0.22	0.222	0.243	0.33	0.2	0.274	0.275	0.3	0.468	0.2
Potassium, K	mg/L	<50	NS	5.459	6.726	7.9	5.531	5.09	5.627	6.735	5.916	6.5	6.126	7.654	5.823	5.166	4.8
Magnesium, Mg (mg/l)	mg/L	<30	NS	41.974	41.109	45.6	46.19	44.413	46.934	40.385	39.501	40.4	45.281	30.766	38.453	44.068	39.1
Sodium, Na	mg/L	<100	<200	43.043	50.443	48.7	46.172	43.981	53.94	53.303	34.728	42	50.177	33.669	47.669	40.168	41
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.136	0.255	0.05	0.216	0.04	0.04	0.268	0.481	0.4	0.321	0.621	0.04	0.233	0.6
pH at 22 °C	pH units	6-9	5-9.7	8.309	8.129	7.7	8.151	8.315	8.217	8	8.194	8.1	8.173	7.913	8.084	8.133	7.5
Sulphate, SO_4	mg/L	<200	<500	111.143	117.457	135	121.402	109.151	105.753	102.636	85.701	111	102.864	75.467	116.88	100.977	101
Ammonium, NH_4	mg/L	<1.0	<1.5	0.123	0.083	0.05	0.184	0.094	0.647	0.112	0.138	0.05	0.159	0.097	0.521	0.114	0.3
Bicarbonate as $CaCO_3$	mg/L	NS	NS	58.52	62.80	51.12	63.59	63.46	58.05	57.83	57.93	48.80	54.03	42.47	62.84	58.77	42.94

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	16/04/2008	23/04/2008	30/04/2008	07/05/2008	08/05/2008	10/05/2008	13/05/2008	18/05/2008	05/06/2008	08/06/2008	03/07/2008	12/07/2008	27/08/2008	03/09/2008
Calcium, Ca	mg/L	<32	NS	50.537	52.336	53.81	54.837	44.6	54.617	55.397	58.497	54.484	56.313	62.9	60.963	73.3	62.695
Chloride, Cl	mg/L	<100	<300	54.074	46.915	48.473	43.11	48	44.098	44.111	46.16	42.978	45.384	47	54.263	58	68.98
Conductivity mS/m @ 25 °C	mS/m	<70	<170	80.3	67.7	69.2	67.5	73	71.1	73.9	-	68	-	82	71.2	90	85.9
Fluoride, F	mg/L	1	1.5	0.24	0.199	0.219	0.213	0.2	0.199	0.194	0.205	0.185	0.196	0.05	-	0.2	-
Potassium, K	mg/L	<50	NS	5.057	4.689	5.425	5.914	4.9	4.539	4.294	4.414	4.521	4.595	4.9	4.199	6.7	6.846
Magnesium, Mg (mg/l)	mg/L	<30	NS	44.94	43.631	46.247	41.633	43.3	47.932	48.958	47.549	45.48	44.81	49.7	49.993	56.6	51.266
Sodium, Na	mg/L	<100	<200	46.306	38.547	39.266	35.512	22	39.295	38.617	40.837	38.919	42.204	41.5	36.846	52.7	51.39
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.368	0.353	0.725	1.021	0.05	0.388	0.362	0.633	0.317	0.485	0.6	0.574	-	-
pH at 22 °C	pH units	6-9	5-9.7	8.233	8.572	8.436	8.32	7.7	8.081	8.198	8	8.103	8.071	8.4	8.402	8.1	8.467
Sulphate, SO_4	mg/L	<200	<500	103.198	104.674	121.287	94.075	118	103.529	102.633	106.355	98.536	111.366	103	116.494	117	125.681
Ammonium, NH_4	mg/L	<1.0	<1.5	0.225	0.09	0.116	0.11	0.05	0.09	0.092	0.122	0.119	0.139	0.2	0.025	-	0.085
Bicarbonate as $CaCO_3$	mg/L	NS	NS	61.66	63.85	65.65	66.90	54.41	66.63	67.58	71.37	66.47	68.70	76.74	74.37	89.43	76.49

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	08/10/2008	29/10/2008	05/11/2008	19/11/2008	26/11/2008	03/12/2008	10/12/2008	24/12/2008	31/12/2008	07/01/2009	14/01/2009	28/01/2009	18/03/2009	01/04/2009
Calcium, Ca	mg/L	<32	NS	65.8	60.5	61.461	61.419	58.369	46.138	61.661	47.297	56.54	40.896	57.071	51.479	46.396	56.919
Chloride, Cl	mg/L	<100	<300	75.4	87.5	65.076	99.029	87.58	58.771	94.312	56.489	71.209	53.971	51.441	64.25	43.215	53.087
Conductivity mS/m @ 25 °C	mS/m	<70	<170	93.2	99.8	77.3	84.7	78.2	64.8	90.3	71.2	82.3	61.8	75.3	78.4	61.3	75.5
Fluoride, F	mg/L	1	1.5	0.05	0.05	-	-	-	-	-	-	-	-	-	-	-	-
Potassium, K	mg/L	<50	NS	6.6	7.68	6.292	9.7	9.314	9.067	9.053	7.705	8.693	6.975	6	8	6.2	5.09
Magnesium, Mg (mg/l)	mg/L	<30	NS	55.1	49.1	61.816	44.93	59.329	32.932	45.038	36.908	47.099	31.496	54.326	38.851	25.638	47.765
Sodium, Na	mg/L	<100	<200	59.8	61.4	41.534	75.6	68.794	47.474	63.297	39.796	47.943	37.722	36	49.4	29.8	38.8
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.04	0.04	0.144	-	-	-	-	-	-	-	-	-	1.097	0.48
pH at 22 °C	pH units	6-9	5-9.7	8.4	8.13	8.342	8.35	8.109	8.267	8.483	8.631	8.376	8.391	8.492	8.51	8.24	8.341
Sulphate, SO_4	mg/L	<200	<500	128	138	130.042	171.331	167.725	87.397	113.663	84.539	87.568	83.226	102.671	114.319	75.196	52.122
Ammonium, NH_4	mg/L	<1.0	<1.5	0.02	0.02	0.025	0.025	0.025	0	0.025	0.08	0.025	0.025	0.025	0.025	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	80.28	73.81	74.98	74.93	71.21	56.29	75.23	57.70	68.98	49.89	69.63	62.80	56.60	69.44

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	08/04/2009	16/04/2009	30/04/2009	01/05/2009	13/05/2009	10/06/2009	26/08/2009	30/09/2009	07/10/2009	14/10/2009	21/10/2009	11/11/2009	20/11/2009	25/11/2009
Calcium, Ca	mg/L	<32	NS	63.477	60.794	61.89	63.758	63.758	67.986	64.473	69.2	68.041	65.187	64.304	58.965	57.468	58.303
Chloride, Cl	mg/L	<100	<300	58.814	57.845	49.669	51.996	51.334	46.274	50.377	73.744	78.301	75.872	72.609	64.564	66.146	60.011
Conductivity mS/m @ 25 °C	mS/m	<70	<170	81.3	79.5	80.2	82.5	79.2	-	81.6	94.4	93.5	94.3	91.7	84.8	84.8	80.8
Fluoride, F	mg/L	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium, K	mg/L	<50	NS	5.89	5.4	4.9	4.8	5.3	4.51	4.8	7.228	7.382	8.5	8.1	7.1	6.3	6.4
Magnesium, Mg (mg/l)	mg/L	<30	NS	72.411	53.039	50.366	53.276	49.482	60.503	44.011	53.826	54.68	56.823	53.684	51.153	49.924	45.652
Sodium, Na	mg/L	<100	<200	47	44.4	35.6	36.4	36.6	33.4	34.8	53.963	56.272	57.5	50.3	50.6	51.5	44.8
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.415	0.671	0.781	0.233	1.079	0.192	-	-	-	-	-	-	-	-
pH at 22 °C	pH units	6-9	5-9.7	8.458	8.399	8.347	7.937	8.624	8.558	8.285	8.269	8.715	8.209	8.27	8.185	8.445	8.162
Sulphate, SO_4	mg/L	<200	<500	123.898	99.876	102.097	103.365	111.257	97.622	104.739	118.36	118.995	115.27	114.402	110.12	118.257	114.417
Ammonium, NH_4	mg/L	<1.0	<1.5	0.025	0.025	0.025	0.025	0.06	0.025	0.025	0.025	0.058	0.025	0.025	0.025	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	77.44	74.17	75.51	77.78	77.78	82.94	78.66	84.42	83.01	79.53	78.45	71.94	70.11	71.13

Exceed the DWA SAWQTV standards

Exceed the SANS standards

Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	01/12/2009	16/12/2009	23/12/2009	30/12/2009	13/01/2010	20/01/2010	27/01/2010	03/02/2010	10/02/2010	03/03/2010	10/03/2010	17/03/2010	31/03/2010	08/04/2010
Calcium, Ca	mg/L	<32	NS	**58.013**	**50.674**	**51.508**	**48.209**	**45.987**	23.673	29.644	**45.595**	**41.092**	**52.234**	**53.897**	**58.501**	**54.84**	**51.103**
Chloride, Cl	mg/L	<100	<300	66.679	60.13	49.539	63.956	54.337	26.316	30.827	33.739	38.304	42.573	45.644	57.797	44.824	41.869
Conductivity mS/m @ 25 °C	mS/m	<70	<170	**83.6**	**72.5**	**72.5**	**70.9**	67.1	13.2	43.9	56.1	56.5	69.7	**72**	**76.4**	**71.5**	65.5
Fluoride, F	mg/L	1	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Potassium, K	mg/L	<50	NS	6.2	6.1	5.6	5.6	5.3	6.9	6.8	11	5.6	4.4	4.4	6.3	4.8	4.8
Magnesium, Mg (mg/l)	mg/L	<30	NS	**47.038**	**37.53**	**39.847**	**36.325**	**34.447**	15.789	19.357	27.135	**34.668**	**48.984**	**42.468**	**44.653**	**43.755**	**37.677**
Sodium, Na	mg/L	<100	<200	52.9	48.6	38.6	50.1	40.5	17.9	24.2	24.5	28.3	31	32	39.1	32.3	31.1
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	-	0.005	0.005	0.303	-	-	0.005	-	0.005	0.242	0.499	1.071	0.774	0.061
pH at 22 °C	pH units	6-9	5-9.7	8.186	7.663	7.362	8.113	7.776	8.264	8.103	7.554	7.883	8.227	8.309	8.282	8.181	8.085
Sulphate, SO_4	mg/L	<200	<500	108.426	89.741	105.203	88.477	88.312	41.129	50.718	24.791	59.277	77.678	78.743	77.341	84.306	82.736
Ammonium, NH_4	mg/L	<1.0	<1.5	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.533	0.025	0.025	0.057	0.071	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	70.78	61.82	62.84	58.81	56.10	28.88	36.17	55.63	50.13	63.73	65.75	71.37	66.90	62.35
Exceed the DWA SAWQTV standards																	
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Parameter (mg/l)	Unit	DWA SAWQTV Drinking Water	SANS 241-1: 2011	14/04/2010	22/04/2010	12/05/2010	26/05/2010	02/06/2010	23/06/2010	01/07/2010	14/07/2010	04/08/2010	20/08/2010	01/09/2010	15/09/2010	10/11/2010	08/12/2010
Calcium, Ca	mg/L	<32	NS	**51.269**	**54.749**	**54.879**	**52.814**	**52.638**	**57.271**	**61.643**	**48.725**	**58.877**	**58.652**	**59.786**	**63.349**	**56.336**	**56.156**
Chloride, Cl	mg/L	<100	<300	38.578	38.67	36.654	28.815	28.925	33.114	37.302	34.848	41.126	40.612	41.399	42.118	59.609	57.398
Conductivity mS/m @ 25 °C	mS/m	<70	<170	65.7	69.7	66.6	61.5	63.2	67.2	64.8	68.4	**70.7**	**72.5**	**75**	**74.9**	**85.7**	**77.1**
Fluoride, F	mg/L	1	1.5	-	-	-	-	-	-	-	0.255	0.289	0.197	0.243	0.217	0.799	0.488
Potassium, K	mg/L	<50	NS	4.6	4.2	3.6	4.1	4.1	4.13	4.3	4.38	4.88	5.143	5.267	4.934	8.629	5.894
Magnesium, Mg (mg/l)	mg/L	<30	NS	**38.987**	**43.801**	**40.601**	**44.377**	**44.159**	**39.357**	**43.186**	**42.516**	**44.14**	**47.04**	**49.545**	**43.147**	**42.977**	**41.706**
Sodium, Na	mg/L	<100	<200	30.8	28.1	22.1	23.9	23.5	24.5	26	27.9	30.6	32.279	31.532	31.822	54.517	44.609
Nitrate, NO_2+NO_3	mg/L	<26.6	<48.7	0.109	0.38	0.005	0.005	0.005	0.371	0.151	0.17	0.309	0.589	0.636	0.99	0.882	0.693
pH at 22 °C	pH units	6-9	5-9.7	8.214	8.172	8.281	7.628	7.542	8.276	8.315	6.828	8.194	8.497	8.459	8.47	8.286	8.297
Sulphate, SO_4	mg/L	<200	<500	75.506	77.365	84.358	57.548	54.42	61.382	70.256	74.902	79.748	79.725	82.03	84.758	104.687	103.459
Ammonium, NH_4	mg/L	<1.0	<1.5	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.071	0.025	0.025
Bicarbonate as $CaCO_3$	mg/L	NS	NS	62.55	66.79	66.95	64.43	64.22	69.87	75.20	59.44	71.83	71.56	72.94	77.29	68.73	68.51
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Parameter (mg/l)	*Unit*	DWA SAWQTV Drinking Water	SANS 241-1: 2011	22/12/2010	30/06/2011	12/07/2011	25/08/2011
Calcium, Ca	mg/L	**<32**	**NS**	**51.923**	**51.524**	**63.986**	**58.823**
Chloride, Cl	mg/L	**<100**	**<300**	49.907	31.92	33.424	36.649
Conductivity mS/m @ 25 °C	mS/m	**<70**	**<170**	**73.6**	69.6	**71**	**73.9**
Fluoride, F	mg/L	**1**	**1.5**	0.187	0.307	0.382	0.352
Potassium, K	mg/L	**<50**	**NS**	6.667	4.233	4.197	4.797
Magnesium, Mg (mg/l)	mg/L	**<30**	**NS**	**35.258**	**39.754**	**40.783**	**43.554**
Sodium, Na	mg/L	**<100**	**<200**	39.928	28.383	29.129	30.632
Nitrate, NO_2+NO_3	mg/L	**<26.6**	**<48.7**	0.025	0.025	0.579	0.346
pH at 22 °C	pH units	**6-9**	**5-9.7**	8.084	8.156	8.387	8.281
Sulphate, SO_4	mg/L	**<200**	**<500**	117.223	74.862	74.515	81.09
Ammonium, NH_4	mg/L	**<1.0**	**<1.5**	0.025	0.325	0.025	0.146
Bicarbonate as $CaCO_3$	mg/L	**NS**	**NS**	63.35	62.86	78.06	71.76

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